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KENYA NATIONAL CROP STORAGE STUDY

Report Prepared for

U.S. Agency for International Development

Project No. 615-0169

Contract No. AID/afr-C-1562

by

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May 1980

EXECUTIVE SUMMARY

The Kenya National Crop Storage Study was sponsored by the U.S. Agency for International Development in Cooperation with the Ministry of Agriculture in Kenya. The study was proposed in a report entitled "Smallholder Grain Storage in Kenya: Problems and Proposed Solutions," February 1978, by the Food and Feed Grain Institute of Kansas State University.

The contract for the study was awarded to Development Planning and Research Associates, Inc. (DPRA) of Manhattan, Kansas. A four-man team consisting of a Team Leader, An Agricultural Economist, an Agricultural Engineer and an Entomologist arrived in Kenya on about September 1, 1979 and completed their work in March, 1980. During the study, other engineering and economist members of the DPRA staff visited and worked with the team on four occasions; each visit was for a period of about one month.

The team was supplied with a secretary, drivers, vehicles, office space and other logistical support by the Ministry of Agriculture.

The month of September was spent in visiting various agencies of the Government of Kenya and USAID to become familiar with the problems of farm and rural grain storage and to learn the interest of various groups in the subject area. During a visit with the Central Bureau of Statistics (CBS) it was learned that they had considered making a study of smallholder grain losses and would cooperate in the field survey. The CBS aided in the selection of farms to be visited, furnished the assistance of their enumerators as interpreters and made available unpublished (from computer files) data which was needed for the project.

From about the first of October through the first half of December, the team travelled in two two-man groups to visit smallholders, rural markets, rural agencies and groups (such as, extension, cooperatives, colleges, farmer training centers, merchants, etc.) and to collect grain samples from farms, markets and other sources. About 190 smallholders were interviewed.

A grain quality laboratory was set up in Nairobi by DPRA to process the samples. It operated from about December 1 to February 1 by DPRA and about 450 (250 from farms) samples were analyzed.

Beginning about the middle of December a series of meetings was held with government agencies to report on observations of the field work and discuss the role which the agency might have, or would be interested in, playing in the project aimed at reducing grain losses.

Agencies which were interested in a role in the project were visited one or two more times to develop project components.

Grain losses are moderately severe in Kenya as shown by the results of the survey. Losses begin in the field before maize is mature. Birds attack kernels on the end of the ear and inflict an estimated 1.3 percent damage. When the maize reaches physiologic maturity, at about 35 percent moisture, it begins to lose some of its resistance to storage insects and mold. The relative humidity in Kenya is relatively high and grain dries slowly in the field before it reaches a low enough moisture to be harvested and placed in traditional cribs for further drying and storage. This period of field drying lasts about one to two months and during this time a loss of about 5 percent due to mold and 1 percent due to insects occurs. Farmers also report some field loss due to rodents but it was impossible to measure this loss.

After the corn, at about 20 percent moisture, is harvested it is placed in cribs for further drying. The drying lasts for about three months; an additional mold loss of about 6 percent occurs. Insect loss is not severe for the first two or three months but begins to increase rapidly reaching a total insect loss of 9 percent after six months, (the normal storage period in two crop regions) and 16 percent after one year in single crop regions.

Insect protectants are used by only 38 percent of the smallholders. However, smallholders realize that losses occur and estimate that they lose about 11 percent of their grain, compared to the estimated loss of 16 percent which was found in this survey.

Losses of this magnitude are significant to the farmer and to the nation. It reduces the net income of the smallholder, and, from the national standpoint, reduces the potential to export (or increases the need to import) grain.

Based upon the results of the survey, the most cost effective program to reduce losses would consist of:

1. Harvesting when the maize is physiologically mature to reduce field losses.

2. Sun drying on platforms until a safe storage moisture of 13 to 14 percent is reached.

3. Shelling about half of the crop, that which will be stored for longer than three months; applying an insect protectant, and perhaps storing in insect proof containers.

As farmers replace cribs they should be of an improved design, narrower to provide better drying and equipped with rat guards on the supports.

The suggested program of early harvest and insect treatment should reduce losses from the present 16 percent to an estimated 5 percent. The investment for the farmer will be an estimated 200 KSh and the return to labor for the farmer is an estimated 3 KSh per hour. Normal wages in the rural area are about 4 KSh per day.

Losses for beans are lower, about 4 percent, than for maize but the same type of intervention, early harvesting, sun-drying and applying insect protectants should be effective in reducing losses.

Sorghum losses may be higher than for maize but the same interventions should be effective.

To implement a program to motivate and train farmers will require an extensive educational and extension program reaching from the rural area up to the University. Research is needed to adapt and test new ideas. A new section within the Ministry of Agriculture is proposed to support and coordinate activities aimed at reducing grain losses.

Project components which are proposed for support include:

1. The establishment of a Post-harvest and Storage Section" within the Ministry of Agriculture.

2. The training of farmers in postharvest and storage technology at Farmer Training Centers.

3. Partial grants to smallholders to construct demonstration cribs and drying platforms.

4. Assistance to Egerton College.

5. Assistance to Embu and Bukura Agricultural Institutes.

6. Assistance to the University of Nairobi.

7. Support to the Central Bureau of Statistics.

8. Research Grants to MOA and University of Nairobi.

9. Support of the Agricultural Information Services.

10. Support of Home Economics and Rural Youth Branch.

11. Support of Land Development Division.

12. Technical Services to the Contract.

The overall projected contributions to the project over five years are:

USAID: $6,529,900
Government of Kenya: KSh $6,740,900 ($936,236)

An economic analysis of the overall benefits of this project was made. The value of each ton of maize saved was taken as KSh 1332/T ($185) which was based upon the cost of maize imported to Nairobi, or is equal to the peak season price.

Reasonable assumptions were made regarding the rate at which farmers adopt the recommended practices. Under the assumptions made it is estimated that 10 percent of the smallholders of Kenya will adopt the improved practices after 15 years. If this rate of adoption is achieved the loss reduction would be 148,000 T at the end of 15 years, and would have a value of KSh 247,620,000 ($34,392,000).

The estimated internal rate of return to total project costs over the 15 year period is 18 percent, and for the Government of Kenya the internal rate of return is 94 percent.

A sensitivity analysis was made to investigate the effect if certain key assumptions were varied. The internal rate of return to total project costs varied from 10 percent to 25 percent depending on assumptions made.

ACKNOWLEDGEMENTS

The contractor, Development Planning and Research Associates, Inc. of Manhattan, Kansas, USA, was proud to have the opportunity of providing the technical services to the Kenya National Crop Storage Study. The technical team is indebted to each person and agency who participated in the field survey work and development of the proposed project which was designed to be of social and economic benefit to many Kenyans.

The Ministry of Agriculture, under the coordination of Mr. George M. Kimani, Deputy Director of Agriculture, set the stage for the team's work. Through his capable efforts, the USA technicians were provided with transportation and experienced drivers, suitable office space with Arid/Semi Arid Lands Branch, and superior secretarial and other services provided by Mr. Charles M. Gichohi and Mr. D.F.M. Kallavi, Head and Deputy of that Branch. Also, Mr. Kimani arranged for consultations with Chiefs and Heads of all relevant MOA Divisions and Branches. During the field survey work the team was always warmly received at Farmer Training Centers, Agricultural Training Institutes and by Provincial and District Personnel. For their strong beliefs in the need for an increased emphasis on reducing postharvest losses, and for their constructive suggestions, the team extends special thanks and appreciation to these professionals.

In particular, recognition is hereby accorded to the nearly 200 smallholders visited and the Central Bureau of Statistics, enumerators, supervisors, provincial and district officers, and central headquarters staff who provided expertise, time and extended much effort in the collection of necessary data and crop samples. Their assistance was a major input to the field survey work.

The team's gratitude is extended to faculty members of the University of Nairobi and Egerton College and to officials of the Ministry of Cooperative Development and Cereals and Produce Board for their contribution to the study design and content of the proposed project.

Very important and useful information was shared with the team by in-country representatives of other donor countries. Special recognition and thanks are extended to Mr. George L.T. Hunt, Tropical Products Institute, Overseas Development Ministry, U.K. (on duty with MOA) and to Mr. Ove Sode of the Food and Agricultural Organization, United Nations.

The USAID Mission to Kenya provided outstanding direction and supervision to the project. The team remains grateful to all participating USAID personnel and acknowledges their invaluable cooperation and support.

It is impossible for the team to adequately convey their appreciation to everyone with whom they worked. All were vitally interested in the total effort and cooperation prevailed to the extent that it became the theme during the team's assignment period in Kenya.

ABBREVIATIONS

AA - Agricultural Assistant
AIC - Agricultural Information Center
CBS - Central Bureau of Statistics
CBK - Cooperative Bank of Kenya
DANIDA - Danish International Development Agency
DAO - District Agricultural Officer
DDA - Deputy Director of Agriculture
DPHSO - District Postharvest Storage Officer
EEC - European Economic Community
expat - Expatriate
FAO - Food and Agricultural Organization of the United Nations
FISS - Farm Input Supply Scheme
FTC - Farmers Training Center
GAT - German Agriculture Team in Kenya
GOK - Government of Kenya
HQ - Headquarters (Nairobi)
IADP - Integrated Agriculture Development Program
IRS - Integrated Rural Survey
JAA - Junior Agricultural Assistant
KSh - Kenya Shilling
MOA - Ministry of Agriculture
MOCD - Ministry of Cooperative Development
NAL - National Agricultural Laboratories
NCPB - National Cereals and Produce Board (formerly, Maize and Produce Board)
NHRS - National Horticulture Research Station
NIB - National Irrigation Board
PCO - Provincial Crops Officer
PDA - Provincial Director of Agriculture
PHO - Post-Harvest Officer
PHSS - Post-Harvest and Storage Section
PMO - Provincial Marketing Officer
PPHSO - Provincial Postharvest Storage Officer
SPPL - Stored Products Protection Laboratory
SPSCP - Smallholder Production Services and Credit Project
TA - Technical Assistant
TPI - Tropical Products Institute
TSPC - Tropical Stored Products Center
UNICEF - United Nations International Childrens' Emergency Fund
UNDP - United Nations Development Project
USAID - United States Agency for International Development

Exchange Rates

7.20 KSh = US$ 1.00
= 0.435 British pounds

Weights and Measures

1 Kg = 2.205 lb
1 metric ton (MT) = 1,000 Kg = 2205 lb
1 bag = 90 Kg

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KENYA NATIONAL CROP STORAGE STUDY

I. INTRODUCTION

The global shrinkage of grain supplies and their importance as a source of human food is reflected as a total of what is happening in many countries. In Kenya today a shortage of maize for food is reported in most areas of the country. Due to several conditions reported by maize growers, fewer acres were planted in 1979. The sales price to the producer was substantially lowered, fertilizer was late in being distributed, and rainfall in most parts of the country was less than in the 1977-1978 growing seasons. In some cases, excess rainfall curtailed an orderly harvesting process in 1979. One important aspect of the supply of food which has received insufficient attention to date pertains to the destruction of food which is produced. What happens to the food which is produced, from the time it is mature, ready for harvest, to the time it is consumed?

During the post-maturity period more commonly referred to as the postharvest period, losses of foods already produced can reach a high percentage of the total production. The more apparent losses are due to consumption by birds prior to (and following) maturity; insects that infest and eat the crops before harvest and accompany the produce into storage where damage continues; methods of handling and threshing which permit losses due to shattering or kernel damage thus making the broken grain more vulnerable to insect attacks; insufficient drying whereby the moisture content is high enough to encourage the growth of molds or rewetting which nets similar results; and rodents that can consume large quantities of grain. A significant amount of these losses, when totalled, can be accounted for as occurring during the postharvest period.

Many observers believe that a 50-percent reduction in postharvest food losses in developing countries would greatly reduce, or even eliminate, the present need of some countries to import large quantities of food. This reduction has been set by the VIIth Special Session of the United Nations General Assembly in 1975 as a target to be achieved by 1985. Annual production of cereals by that time is projected to reach 450 million tonnes, and projected minimum losses might amount to at least 45 million tonnes, valued at 7.4 billion 1974 U.S. dollars.

Food losses are highly locality-specific, not only in amounts, but also in their impact: this means they must be evaluated in the context of the relative economics of food production and of the relationship between food production and population growth. There is no doubt, however, of the importance of loss reduction to governments and technical assistance agencies as a means

of increasing food availability at a time when constraints on production (decreased land availability and rising costs of fertilizers and pesticides) are continually increasing.

To plan for the reduction of losses of stored cereal grains and grain legumes (pulses), the Government of Kenya requested assistance from the USAID Mission to Kenya. The latter agency in Washington, D.C., USA, contracted with the Food and Feed Grain Institute, Kansas State University, Manhattan, Kansas, USA, to assist USAID/Nairobi in preparation of a project paper by defining and detailing proposed AID - funded assistance in grain storage. The team of two was asked to address the grain storage needs of the smallholder farmers and rural co-operatives. The report was entitled, "Smallholder Grain Storage in Kenya: Problems and Proposed Solutions," February, 1978. The smallholder farmers (those with 8 hectares or less for an average of 2.4 hectares per holding) were a major focus because of the large number in Kenya and the large proportion of the maize sold that comes from smallholdings.

As a result of the above survey, the Kenya National Crop Storage Study was instituted. It was designed to determine the causes of losses in Kenya during the postharvest period of major food grains and legumes (pulses). The technical team was to develop a project designed to reduce losses of smallholder farmers; the project was to be designed to develop the capabilities of government educational facilities, services, and institutions for a permanent basis of support to a nationwide postharvest loss reduction program.

The work was conducted under the auspices of the U.S. Agency for International Development Mission to Kenya (USAID/K) in cooperation with Government of Kenya (GOK) by contract No. AID/afr-C-1562 with Development Planning and Research Associates, Inc. (DPRA), Manhattan, Kansas, USA who provided the study team staff to the project as follows:

Name	Position	Period in Kenya
Dr. Ulysses A. Acasic	Agricultural Engineer	4 Sept 79 - 17 Mar 80
Mr. Christopher Gerrard	Agricultural Economist	4 Sept 79 - 14 Mar 80
Mr. Michael Hanrahan	Agricultural Economist	14 Jan 80 - 18 Feb 80
Dr. Duane Loewenstein	Team Leader	25 Aug 79 - 15 Mar 80
Dr. Harry Pfost	Project Director	24 Aug 79 - 16 Sept 79
		24 Oct 79 - 10 Nov 79
		25 Feb 80 - 25 Mar 80
Dr. T. O. Thatcher	Entomologist	4 Sept 80 - 2 Mar 80

The study team investigated and reported on the following project opportunities as directed by the contract:

"1. Development of a program for storage-related training needs.

a. Provide the specialty skills such as agricultural engineering, entomology and extension personnel.

b. Identify the personnel at all levels with NAL staff, extension staff and other MOA groups which may require further training in food storage.

c. Delineate those training courses and institutions for training the personnel selected.

"2. Design storage and drying units for FTC's (demonstrations) appropriate for smallholder farmers, taking into account the climatic variations and utilization of local materials and equipment which can be fabricated locally.

To provide:

a. specifications
b. cost estimates
c. working drawings, and
d. operating instructions for the structures and equipment.

For:

a. storing and drying ear maize
b. threshed cereals and pulses
c. potatoes

Note: The number and size of each kind of storage and drying unit to be built at each FTC shall be determined.

"3. Design loans to smallholders to build storage structures for ear and shelled maize, threshed beans, and sorghum/millet.

a. Evaluate demand by smallholders for loans for the building of storage structures.

b. Identify appropriate lending institutions and recommend credit procedures for extending and monitoring loans.

c. Specify the technical assistance, training and supervision required for construction according to specifications.

Note: Such training for construction may be given to extension personnel, farmers, carpenters and teachers at polytechnics.

"4. Design loans to cooperative unions/societies (same as 3, a-c above as applicable). Determine expected number of units to be built and size required.

"5. Design research for the storage and drying of ear maize, shelled maize and threshed grains.

a. Evaluate research needs related to drying, storing and marketing grains at the farm and cooperative levels.

b. Determine relevant applied research areas including:

(1) appropriate technology,
(2) integrated pest control,
(3) transportation,
(4) pricing problems, and
(5) cooperative financial management problems.

c. The following shall be specified:

(1) approximate location,
(2) institution,
(3) personnel,
(4) apparatus,
(5) equipment,
(6) supplies,
(7) expenditure, and
(8) time duration of the projects."

In order to investigate and report on these five project opportunities, the team members, upon arrival in Kenya, immediately began their orientation in developing an understanding of and an appreciation for postharvest and related problems in Kenya. Relevant written information was located and a close liasion was developed with Government of Kenya and donor agency officials who were cognizant of and could be helpful with solving postharvest problems. The field survey components were designed, the questionnaires developed, and the field trip and sample and data gathering schedules planned in cooperation with the Central Bureau of Statistics (CBS) (See Chapter III--A. The Survey, for details). The major portion of the field work was completed between mid-October and the first of December, 1979.

The necessary equipment was shipped to Nairobi for a laboratory which was under the supervision of a qualified technician. Grain samples were assessed for damage and loss and assays were performed for the presence of aflatoxin. The laboratory work was completed in early February.

The field data were tabulated and analyzed beginning in November and finished in January. Report writing began in January after consultation with cooperating Government of Kenya officials.

II. BACKGROUND INFORMATION ON KENYA

A. Smallholder Production of Grains

1. The Geography and Climate of Kenya

Kenya, an equatorial country, has a landscape that is frequently interrupted by mountains and hills which produce extreme variations in altitude and climate within very short distances. Mt. Kenya, directly on the equator, rises to 5,199 meters. To the east the land slopes gradually to sea level at the Indian Ocean over a distance of about 500 kilometers. To the north it falls more rapidly to about 500 meters in the northern Kenyan desert. Toward the west the elevation generally remains above 1,500 meters most of the way to the Uganda border except along the shore of Lake Victoria where the elevation drops to 1,133 meters. This highland region is divided by a geological formation known as the Great Rift Valley which extends from the Republic of South Africa to Israel and the floor of which attains its greatest height, 1,980 meters, in Kenya. To the immediate east of the Rift Valley, the Aberdare Mountains rise to 3,999 meters; to the immediate west, the Mau Escarpment rises to 3,098 meters.

Altitude and rainfall are closely associated. In general, up to about 2,500 meters, the higher the elevation, the greater and more reliable the rainfall, the longer the effective growing season for agricultural crops, and the higher the agricultural potential of the land. The major exception to this rule is the coastal region which also receives adequate rainfall for sedentary agricultural purposes due to its proximity to the Indian Ocean. The Ministry of Agriculture has classified as "high potential" land which receives an average of 857.5 mm rainfall or more annually (980 mm or more in Coast Province). This constitutes approximately 12 percent of Kenya's land area, most of it concentrated in the southwestern part of the country.

2. The Provinces and Selected Food Crops Grown in Kenya

Kenya is divided into seven provinces for administrative purposes, Figure II-1. Maize is grown in all except the northeastern province. Table II-1 shows the approximate harvest dates for maize; harvests occur almost throughout the year in some provinces.

Yields vary greatly. In 1975, yields ranged from an average of 4.1 tons per hectare in the higher parts of Nyanza and Western Provinces to 0.7 tons per hectare in the lower parts of Eastern Province; the reliability of

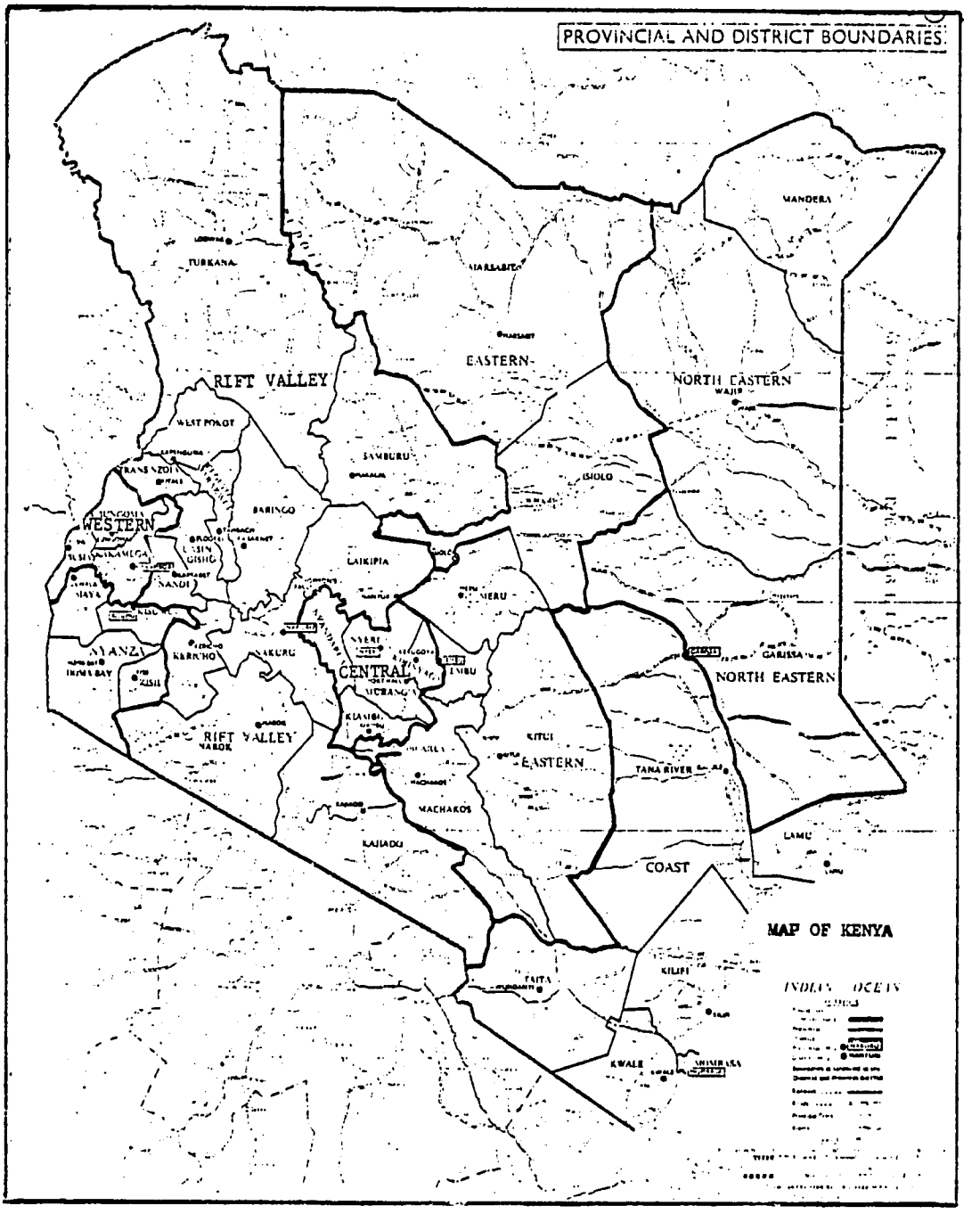

Figure II-1. Provincial and district boundaries of Kenya.

Table II-1. Maize harvest times

Province	District	Zone	J	F	M	A	M	J	J	A	S	O	N	D
Central Province	Kiambu	Upper						LH						
		Lower	K	H						K	KLH	LH		
	Murang'a	Upper	LH	LH	LH									
		Middle	LH	LH						LH	LH			
		Lower	K	KH	HL			K	KLH	LH				
	Kirinyaga	Upper								LH	LH			
		Middle		LH	LH					LH	LH			
		Lower						K	KLH	LH				
	Nyeri	Upper	LH											LH
		Middle		LH	LH						LH	LH		
		Lower		K					K	KLH				
	Nyandarua	-	L	L										
Eastern Province	Embu	Upper								LH	LH			
		Middle	LH	LH					LH	LH				
		Lower	KLH	LH				LH	KLH					
	Meru	Upper							LH	LH				
		Middle	LH	LH						LH	LH			
		Lower	LH	LHK	K			LH	LH					
	Machakos	Upper			LH				LH	LH				
		Lower	K	K				K	KLH					
	Kitui	-		K	KLH			K	KLH	LH				
Rift Valley Province	Nakuru	Upper										LH	LH	
		Lower									LH	LH	LH	
	Elgeyo Marakwet	Upper	LH									LH	LH	LH
		Lower										LH	LH	
	Uasin Gishu	Upper											LH	LH
		Lower											LH	LH
	Nandi	-										LH	LH	
	Kericho	Upper							LH	LH	LH			
		Lower							LH	LH	LH			
	Trans Nzoia	-										LH		LH
Western Province	Busia	-	LH						LH	LH				LH
	Bungoma	Upper		LH							LH			
		Lower		LH							LH			
	Kakamega	Upper	LH							LH			LH	LH
		Lower	LH							LH	LH			LH
Nyanza Province	Siaya	-							LH	LH			LH	LH
	Kisumu	-	LH							LH				LH
	South Nyanza	-	LH					LH	LH					LH
	Kisii	Upper	LH	LH					LH	LH	LH			
		Lower	LH	LH					LH	LH	LH			

L = Local Maize, H = Hybrid Maize, K = Katumani Maize

Source: Kenya, Crop Calendar for Kenya: Planting and harvesting dates of the main crops grown in six provinces, Ministry of Finance and Planning, CBS, 1972.

rainfall is almost as important as the average annual rainfall. Generally speaking, for the same elevations, the farther west in the country, the more reliable the rainfall.

Beans are grown in all areas where maize is produced. However, on a comparative basis they are more predominate in Central and Eastern Provinces, due, at least in part, to a reported dietary preference. Yields are less than 150 kilos per holding. More than two-thirds of the bean production is used for home consumption. In general, beans are harvested from one to two months earlier than maize.

3. Smallholder Production of Food Crops

Kenya is a country of smallholders who cultivate small acreages on an intensive scale, primarily to provide food for the family. Table II-2 presents the population of the country by groups, showing the importance of the smallholding group.

The smallholding population lives in areas without the amenities available to urban people. In Kenya most of the disadvantaged, as well as the low income people, are the smallholders and their families. Smallholders are a predominate source of food, including marketed food. Not all the smallholders are full-time farmers; approximately 400,000 of them (23.5 percent) have other major occupations, and 100,000 (5.7 percent) have a secondary occupation of importance in addition to managing their holdings as their primary source of income. In many other smallholder families one or more members, other than the holder, has an additional source of income [Casley and Marchant (1)]. The holders with the smallest holdings do market, on average, a significant part of their production. However, the value of sales does not increase in proportion to the increase in size of holding. Table II-3 shows the distribution of smallholdings by size. Seventy-five percent of the holdings consists of less than two hectares each. The larger of the smallholdings tend to be located in the more arid areas.

Nearly all smallholders grew maize in 1974-1975. Table II-4 shows that hybrid maize is being grown in the six producing provinces but varies by province. This is due, in part, to the fact that hybrids developed and introduced perform better in Rift Valley, Western and Central Provinces than in the other maize producing areas, and government sponsored programs are encouraging the production of the higher yielding hybrid varieties in those areas. The second most popular crop according to number of growers was beans. Nearly 70 percent of the smallholders grow beans. Well over 80 percent of the Central, Eastern and Western smallholders were bean producers while approximately 30 percent were bean growers in Nyanza, Rift Valley and Coast Provinces.

Table II-2. Estimated population of Kenya, 1977, by groupings

Grouping	Estimated 1977 population ('000's)	(Percent)
On Smallholdings	10,464	72.9
Urban	1,391	9.7
Rural, Non-agricultural	1,229	8.6
Pastoral	672	4.7
Large farms	592	4.1
Total	14,348	100.0

Source: Casley and Marchant: Smallholder Marketing in Kenya, 1979.

Table II-3. Distribution of smallholdings by size

Size of holding (hectares)	No. ('000's)	Holdings percent
Below 0.5	508	30
0.5 - 0.9	405	24
1.0 - 1.9	362	21
2.0 - 2.9	156	9
3.0 - 3.9	88	5
4.0 - 4.9	59	4
5.0 - 7.9	67	4
8.0 and over	59	3
Total	1,704	100

Source: IRS 1976-1977.

Table II-4. Percentage of smallholders growing selected crops by province, 1974-1975

Crop	Nyanza	Western	Rift Valley	Central	Eastern	Coast	Kenya
Local maize	80	74	59	95	99	94	86
Hybrid maize	36	73	92	67	30	19	50
Beans	39	79	22	98	86	28	69
E. Potatoes	1	-	8	86	52	2	32
Sorghum	75	37	1	1	16	2	30
Millet	33	45	51	-	19	-	24

Source: Casley and Marchant, derived from IRS-I.

English potatoes were grown by almost one-third of the smallholders, but, these were mainly concentrated in Central and Eastern Provinces.

Of the smallholders in Nyanza Province 75 percent grew sorghum and 33 percent were millet producers. In Rift Valley Province, of those two crops, millet was popular with 51 percent of the small farmers while only 1 percent produced sorghum. Millet and sorghum were of nearly equal popularity in both Western and Eastern Provinces although the latter had fewer smallholders involved in production.

Maize and beans are major supplies of food for most Kenyans. Smallholder farmers produce these for family consumption and for market sales. Table II-5 shows smallholder maize and bean production for 1977-1978.

Nationally, smallholders produce 80 percent of the total grain and supply 55 percent of the grain marketed.

4. The Storage of Maize on Smallholdings

Table II-6 presents estimates of maize stored and disposed of by smallholders according to months since the previous harvest on a national basis. The data does not imply simultaneous production but describe what happens from the time of harvest through the period of time in storage. They are

Table II-5. Estimated smallholder maize and bean production, 1977-78 (million, 90 kg bags)

Province	Maize		Beans	
	1977	1978	1977	1978
Central	2.16	1.23	0.65	0.58
Coast	0.57	0.60	-	0.02
Eastern	1.59	2.07	0.46	0.61
Nyanza	2.32	1.93	0.16	0.11
Western	1.34	1.77	0.22	0.18
Rift Valley	5.24	6.73	0.09	0.14
Total	13.22	14.33	1.58	1.64

Source: Crop Forecast and Crop Review, 1979.

to be interpreted as indicating the amount disposed of during the first, second and each subsequent month until depleted regardless of the month it may have been harvested. Stored maize is disposed of either through consumption, sales, or losses.

One critical assumption was necessary in order to derive these estimates from unpublished Integrated Rural Survey IV (IRS-IV) data: the smallholders deposit and withdraw maize on a first in, first out basis. This assumption has the effect of minimizing the length of time in storage, and also minimizes the estimate of loss in storage calculated in Section V-E.

Appendix Table II-1 shows the data by province which was used to compile Table II-6 presented by the five major maize-producing provinces.

The amount of maize in storage on a national basis in months from the previous harvest is shown in Figure II-2; the same graph shows a storage curve based on equal disposal in every time period falling to zero after 12 months in the one-crop areas (Rift Valley Province) and after 6 months in the two-crop areas. There is a strong resemblance between the two storage curves. It should not be surprising that in actual experience, farmers tend to dispose of their maize more quickly immediately after harvest than several months later.

Table II-6. National estimates of storage and disposal of maize on smallholdings (in '000's of bags)

Month	In store beginning of month	Disposed of during month	Remained at end of month
0-1	14,880 1/	2,370	12,510
1-2	12,510	2,606	9,904
2-3	9,904	1,828	8,076
3-4	8,076	2,159	5,917
4-5	5,917	2,291	3,626
5-6	3,626	1,416	2,210
6-7	2,210	431	1,779
7-8	1,779	260	1,519
8-9	1,519	434	1,084
9-10	1,084	463	621
10-11	621	511	110
11-12	110	110	0

1/ The provincial totals do not add to the reported national sum due to the exclusion of Coast Province which produces a very small portion of the national production.

Source: Integrated Rural Survey - IV 1978-79. Unpublished data by Central Bureau of Statistics.

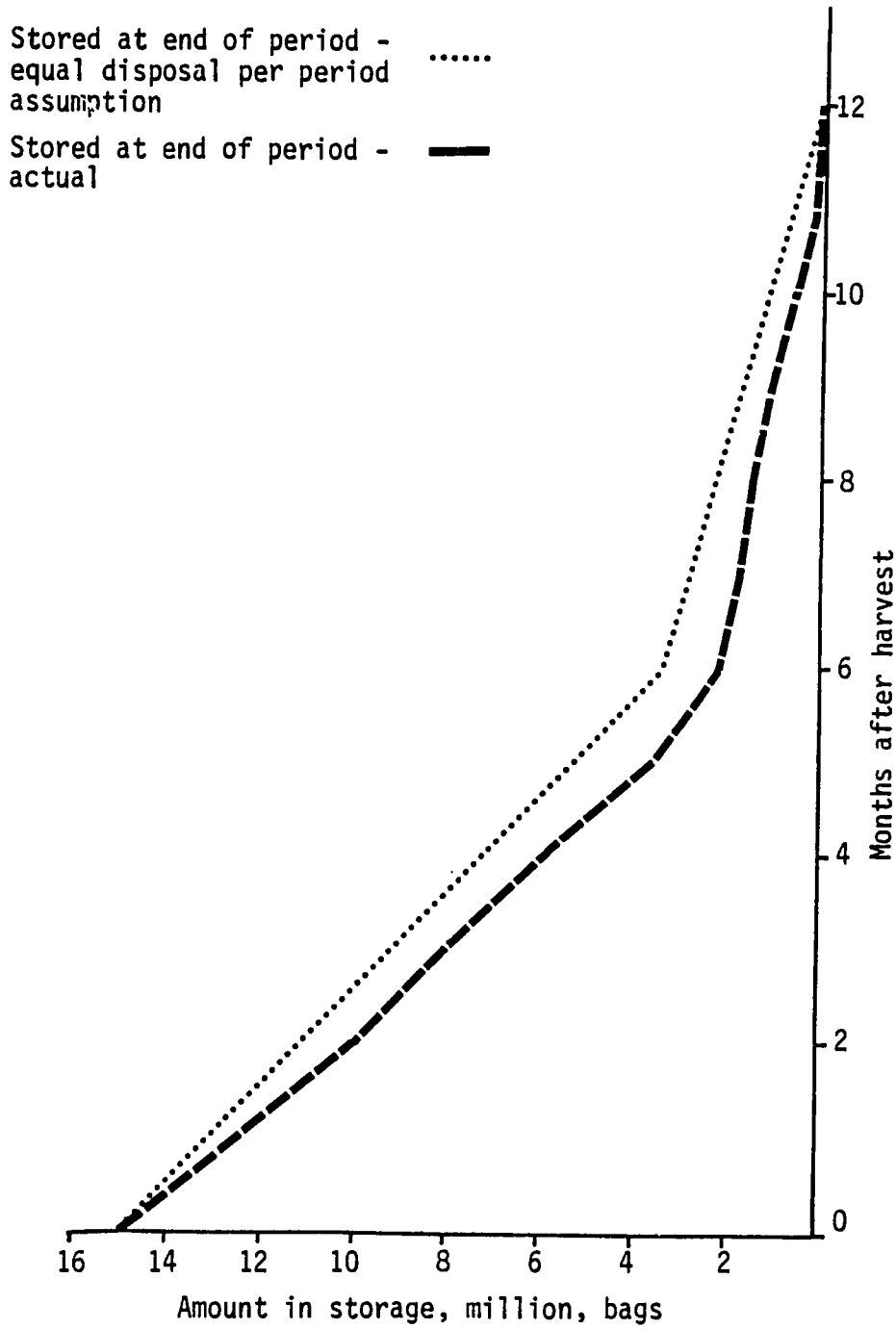

Figure II-2. Maize in storage by time after harvest

B. The Level of Nutrition in Kenya

There is no official nutrition survey done for this report. However, sufficient information can be gleaned from several reports and studies to infer that malnutrition in Kenya is an important problem and a major obstacle to development. This is reflected in the Five-Year Development Plan which has placed heavy emphasis on improving food crops and developing agriculture in general.

From an analysis of existing reports, it is obvious that the rural diets which can be called "subsistence diets" are mainly based on maize and other cereal grains which account for over one-half of the total calorie supplies of food. This diet is conditioned by the level of production, low level of education, and tradition (which gives first choices to males). The result is that the head of the family can enjoy an abundant and satisfactory diet when the harvest is in while the youngest girl and the pregnant or lactating mother in the family become victims of malnutrition during the weeks before the crops start coming in.

The staples of the diets, of course, vary with location and time of the year, but maize is dominant in all areas and is the basic food in all provinces except in the arid and semi-arid areas where millet and sorghum are the dominant crops. Legumes are the main source of protein in almost all provinces.

The average per capita daily requirements of the small farm holders for energy and protein are estimated to be 2,315 kilocalories and 62.5 grams respectively. FAO (2) estimates the energy requirement for Kenya to be 2,320 kilocalories.

The daily per capita food supply of the small farmholders from maize and beans are estimated to be 1,690 kilocalories and 49 grams protein, an average per capita adequacy of 73 percent and 78 percent respectively.

The food resources of the country, insofar as they can be measured, are inadequate on the basis of known figures. The estimated smallholder maize production for 1977-1979 is about 14.88 million 90-kilogram bags of maize and 1.94 million 90-kilogram bags of beans. Given allowances of about 17 percent for waste and other losses for maize, and about 5 percent for losses in beans, the food supply can be estimated at about 145 kg maize and 26.7 kg beans per capita per year. This is equivalent to 616,900 Kcal and 18,000 gm of protein which is less than the required 845,000 kilocalories of energy and 22,800 grams of protein. Of course, this kind of computation is arbitrary and gives only an order of magnitude. There are obviously other sources of calories which are not included in the above figure. Other cereals and grains, potatoes, and tubers undoubtedly greatly strengthen the daily food intake. Even with all these factors, the basic dietary picture is at best still marginal, considering the physique of the people, the burden of their workload, and the unevenness of food distribution. Under the circumstances which prevail in Kenya, there is no doubt that while some people have more than the average

food intake, many have less. It is no wonder that malnutrition is one of the recognized causes of death, with children under 5 forming the most vulnerable group. FAO (2) reports the incidence of protein-energy malnutrition among children to be 26 percent. In 1974, there were about 3,722,000 people or 30 percent of the total population whose caloric intake was below the critical limit of 1.2 BMR.

C. The Problems of Grain Storage

In order to store grain successfully, some basic prerequisites must be met:

1. the grain must be mature and dry,
2. there must be an environment where the grain's original quality is maintained, and
3. the grain must be safe and secure.

The first twc requirements are agronomic and physical in nature while the third is both physical and political.

The responsibility for meeting prerequisite one resides with the producers. Current cultural and agronomic practices among small farm-holders present some problems in meeting the first prerequisite. In places where rainy conditions prevail during harvest, drying the grain quickly by natural means becomes a major problem.

The second prerequisite, which is as critical as the first, concerns farmers, traders, government, private marketing organizations, and grain processors. To meet this storage condition, the stored grain must be maintained such that its moisture will remain at a safe level (usually 13 percent or less) to prevent molding and it must also be protected from insects and rodents.

Thirdly, the safety and security involved in successfully storing grain cannot be overemphasized; it is imperative that it be kept safe from physical destruction and secure from overt or covert pilferage.

Climatological conditions play a major role in grain storage. Warm temperatures, like those in Kenya, foster the rapid reproduction of insects; high relative humidities and temperatures are favorable for the growth of molds and high relative humidities delay the drying of grain before harvesting. Most storage molds must be in a relative humidity of over 70 percent to grow.

Published weather data in Kenya do not contain 24 hour relative humidity data. The data exists on magnetic tapes but the team was unable to secure the data from the Meterology Department. This data should be compiled for all stations to isolate regions or microclimates where average relative humidities of over 70 percent exists for sustained periods (i.e., a few months).

Available published data, Appendix Figure A-II-1 and Table A-II-2 to 5, show that daytime humidities which are quite low are typical for most of the country. Excepting probably the coastal area and possibly some areas near Lake Victoria, relative humidities probably average below 70 percent most of the time. The same data shows low daytime humidities and few rainy days per month which should make sun drying effective.

D. Role of Women in Agriculture

Women play an important role in agriculture in Kenya. The Integrated Rural Survey, 1974-75, reported that 24 percent of small farm households are headed by women; the respondents in this study were 44 percent women. The role of women in maintaining grain quality is probably much higher because woman do a very large part of the postharvest activities including shelling and threshing.

This role of women in agriculture is recognized; women trained in home economics at Egerton College receive two years of common training with the men in agricultural subjects. There is also a common curriculum for men and women at Embu and Bukuru Institutes. Most of the graduates from these three institutions become agricultural extension workers.

The number of women in extension work is still much smaller than the number of men.

The problem of training women farmers is being recognized and a recently instituted Peace Corps project in Kenya is to be devoted to improving the role of extension in reaching women. A recently announced FAO project in Kenya also addresses this problem of helping to improve the training of women farmers in agricultural subjects.

The Tropical Products Institute, United Kingdom, has a major project on farm grain storage loss reduction in Malawi. They believed that the problem of reaching women farmers was a major constraint and have placed a long term female extension specialist in the country to develop the educational program to reach women.

Large numbers of formal and informal women's groups exist in Kenya; these include: community development groups, work groups and other groups which unite to carry out projects of mutual benefit. These groups may provide a logical means of reaching women farmers for training in grain storage. It has been reported that male extension workers can work with women's groups but not individually with women although it is probably better to use female extension workers as the technical resource person.

E. Review of Pertinent Literature

In a study supported by USAID, the National Academy of Sciences published a report "Post-harvest Food Losses in Developing Countries" (3). This publication contains a very extensive bibliography of literature pertaining to food losses. This report estimates maize losses of 9.6 to 20.2 percent as reported by FAO.

One of the first studies of farm grain losses was reported by Shulten (4) based on a study of losses in stored maize in Malawi between 1968 to 1972.

He reported overall insect losses of 1 to 3 percent at the farm level but found that if hybrid maize varieties had been used, rather than harder local varieties, the losses would have been in the 5 to 10 percent range.

Farm losses of maize stored on farms in Zambia were reported by Adams and Harman(5). In this analysis of the economic return to improved storage structures and practices they used a loss of 13 percent as a mean loss obtained from observed losses at various locations throughout Zambia. They estimated that the loss could be reduced to 1.1 percent by improved stores and the use of insecticides. They estimated average cost-benefit ratios of 1:2.4 for the use of insecticides and 1:5.7 for the use of improved storages and practices including shelling and use of insecticides.

Boxall, et al.(6) studied rice losses in farm storages in a small region of India. They concluded that favorable cost benefit ratios could be obtained for modifications to existing systems but not for major modifications such as substituting metal bins for bins made from local materials.

A standard methodology for measuring losses has not yet emerged. USAID sponsored a project on "Post-harvest Grain Loss Assessment Methods," Harris and Lindblad(7). This methodology has not been field tested but reference was made to some of the concepts in the present study.

In a project paper "Reducing Farm Level Grain Storage Losses," USAID Project No. 931-1322 (8), a methodology was proposed which incorporated some of the methodology from Boxall and Harris and Lindblad. The methodology was not appropriate for this project but has been suggested for one of the project components.

Many of the ideas for developing and implementing the project proposed here are discussed in "Priorities for Action in Grain Post Harvest Loss Reduction" (9).

In an unpublished paper "The Assessment of Losses Due to Insects and Rodents in Maize Stored for Subsistence in Kenya" (10), De Lima estimates average annual insect losses of 4.5 percent and rodent losses of 1.45 percent. No estimates of mold losses were given. He estimated insect losses at harvest of less than 1 percent.

Much of the production and price data used in this report came from publications of the Central Bureau of Statistics (CBS), Ministry of Finance and Planning. One of the most basic publications which was frequently used was the Integrated Rural Survey, 1974-75(11). Additional information on production and consumption was taken from CBS unpublished data for later years.

Production data was taken from other CBS reports (12), (13).

Price data was taken from "Time Series Analysis of Basic Commodity Prices" (14).

In formulating components of the project, consideration was given to linkages upward from the farm through the marketing system. "Smallholder Marketing in Kenya" (1) provides detailed data on the characteristics of the smallholder, the magnitude and prices of his sales (and purchases) and discusses other important factors related to smallholder marketing.

A more general report on agricultural marketing development (15) describes the smallholder economy, the marketing problems and the marketing infrastructure. It provides some recommendations for improvements needed in this sector.

"The Marketing of Maize and Beans by Cooperatives in Kenya" (16) discusses the role of cooperatives in grain marketing and enumerates many of the constraints they face.

A detailed study of grain marketing (17) analyzes the functioning of the Kenyan domestic maize and beans marketing system with regard to the interaction of the formal and informal subsystems.

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III. METHODOLOGY

A. Methodology of Grain Storage Survey Conducted by the Team

The major portion of the information the team collected on grain storage practices and losses came from a sample survey of smallholders in Kenya. The time and resources available were limited for the survey; therefore, considerable care was taken to ensure that the sample was random and that it covered important production and ecological grain production zones.

The objective was to visit approximately 200 smallholder farms and to collect approximately 200 samples of maize, 100 samples of beans, and 30 samples of sorghum and millet that were stored. Another 170 samples were to come from rural markets, National Cereals and Produce Board depots, Cooperative union/societies, Agricultural Research Stations, FTC's and maize millers.

The team was fortunate to receive the cooperation of the Central Bureau of Statistics in designing the sample and carrying out the survey. To obtain a representative picture of Kenya, it was decided to visit 14 smallholders in each of 14 districts. Because maize is the staple food in Kenya, each of these smallholders was to be a producer of maize with a likelihood of having some maize in store from the previous harvest.

The districts were selected on the advice of the Bureau as representative of the major maize-producing districts in the country. These were South Nyanza and Kisii in Nyanza Province; Bungoma and Kakamega in Western Province; Kericho, Nandi, Nakuru, Uasin-Gishu and Trans-Nzoia in Rift Valley Province; Kirinyaga and Murang'a in Central Province; and Machakos, Embu, and Meru in Eastern Province. In each of these districts, the Bureau had 4 to 18 sampling clusters forming a national sample which were utilized during their third and fourth integrated rural surveys. Each cluster contained up to twenty smallholders.

At this point, a slight bias was introduced into the sample. The team was going to be visiting some districts in the country almost one year after the previous harvest of maize. Therefore, in order to maximize the possibility of obtaining samples of maize when visiting the smallholders, two clusters were selected in which at least seven farmers had produced more than six bags of maize at the most recent harvest. Then in each of these clusters, a random sample of seven farmers was selected from those who produced more than six bags of maize. In this way a random sample of seven smallholders in each of two clusters in each of the 14 districts was selected, making a total of 196 in all. In addition, three alternates were selected in each cluster also randomly from those households producing more

than six bags of maize. This was done in case some of the primary respondents had moved out of the cluster or were not home on the day the team visited the holding. The team visited 188 out of 196 households.

The upward biases introduced into the sample by the method of selection averaged 76 percent over the entire sample. Table III-1 shows a comparison by districts of the average production of maize by the households in our sample with the average production of maize by all maize-producing households in the district, for the long rains season of 1978 in single crop areas and short rains season of 1978/79 plus the long rains season of 1979 (forecast) in double crop areas.

The districts in Rift Valley and Western Provinces were visited during the last three weeks of October 1979 and the districts in Nyanza, Central, and Eastern Provinces during the montn of November.

At the time of the visit to each smallholder, an enumerator from the Central Bureau of Statistics conducted the interview and completed the questionnaire while a team member made observations concerning the storage facilities and collected samples of whatever grains were on hand. A sample smallholder questionnaire and observation sheet is in Appendix Chapter III.)

Table III-2 shows the number of farms visited and the number of samples of maize and beans collected by province. The team surpassed its objective for samples of maize but fell short for beans. On a province basis, the number of samples collected corresponds closely to the relative production of maize in each province, as Table III-3 shows. Western and Eastern Provinces are over-represented while Nyanza and Rift Valley are under-represented.

To derive an estimate of postharvest grain losses, it is necessary to have a good geographical representation of grain samples and also a good representation of samples over time--that is, that some samples should have been in storage a long time and others a short time. Table III-4 shows the timing of the collection of samples in months from the previous harvest. While very few samples of beans were collected beyond 3-4 months in storage, a considerable number of maize samples were collected up to 10-11 months in storage.

Two unique geographic areas were not included in the original design because of the relatively low production in the area. To compensate, team members visited the Kitui district (semiarid) and Coast Province (tropical) and with the assistance of officials of the Ministry of Agriculture, visited a number of smallholdings in these areas.

Table III-5 shows the number of samples, 151, collected at off-farm points. The majority came from village markets. These samples together with the 320 collected on farms provided a total of 471 samples for laboratory analysis.

Table III-1. Average maize production (bags) 1979: Comparison of households in grain storage survey with maize producing households in each district

District	No. of farms interviewed	Average maize production, 1979		Upward bias (percent)
		Households in grain storage survey	All maize producing households in district	
S. Nyanza	14	9.6	5.8	65.5
Kisii	14	8.2	8.4	-2.4
Bungoma	14	22.7	16.2	40.1
Kakamega	14	13.2	5.7	131.6
Kericho	14	34.1	13.9	145.3
Nandi	14	18.2	20.0	-9.0
Nakuru	14	14.0	7.9	77.2
Uasin-Gishu	13	12.7	12.6	0.8
Trans-Nzoia	14	12.0	10.2	17.6
Kirinyaga	14	12.4	7.3	69.9
Murang'a	13	10.8	6.1	77.0
Machakos	13	14.5	6.5	123.1
Embu	14	13.0	7.7	68.8
Meru	9	28.0	4.1	582.9
14 districts	188	15.8	9.0	75.6

Table III-2. Number of grain samples collected by province

District	Farmers visited	Samples collected: Ear maize	Shelled maize	Total maize	Beans	Sorghum/ millet	Total
Nyanza Province	28	27	0	27	5	11	43
Western Province	28	29	19	48	16	7	71
Rift Valley Province	69	44	25	69	21	6	96
Central Province	27	22	3	25	5	--	30
Eastern Province	36	31	32	63	13	4	80
Total	188	153	79		60	28	320
		232					

Table III-3. Comparison of maize production with number of samples collected by province

Province	Total 1977	Smallholder maize production (million-bags): 1978	1979 1/	Percent of total (Average 1977-1979)	Percent of maize samples collected
Nyanza	2.32	1.93	1.90	14.5	11.6
Western	1.34	1.77	1.72	11.4	20.6
Rift Valley	5.24	6.73	7.00	44.7	29.7
Central	2.16	1.23	1.93	12.5	10.7
Eastern	1.59	2.07	1.94	13.2	27.0
Coast	0.57	0.60	0.39	3.7	0.0
Total	13.22	14.33	14.88	100.0	100.0

Source: Central Bureau of Statistics, Crop Forecast and Review, 1978 and 1979.

1/ Forecast

Table III-4. Samples collected by time after harvest

Months since harvest	No. of samples collected		Total maize	Beans
	Ear maize	Shelled maize		
0-1	33	19	52	5
1-2	22	8	30	7
2-3	30	11	41	10
3-4	31	18	49	25
4-5	12	1	13	5
5-6	1	0	1	4
6-7	1	0	1	1
7-8	2	1	3	0
8-9	4	11	15	0
9-10	9	7	16	3
10-11	6	4	10	0
11-12	3	0	3	0
Total	154	80	234	60

Table III-5. Other grain samples collected

	Maize	Beans	Sorghum/millet	Total
Kitui district - Smallholders	8	1		9
Coast Province - Smallholders	4			4
Rural markets	45	22	15	82
National Cereals and Produce Board depots	24	4	--	28
Cooperative unions	--	2	1	3
Agricultural research stations	9	--	--	9
FTCs	6			6
Maize millers	10			10
Total	106	29	16	151

B. Laboratory Methodology

A grain quality assessment laboratory was set up in a private home in Nairobi. The laboratory equipment, brought into the country by the Grain Storage Team, included:

- Dockage sieve set
- Moisture meter (portable, capacitance type)
- Magnifying glasses
- Balance scale
- Ultra violet light
- Rapid Screening kit for aflatoxin assay (Holaday Method)

1. Assessment of Damage to Ear Maize

When samples of ear maize were collected from farm stores they were first evaluated by the entomologist. The entomologist devised a method based on past experience and information from literature to achieve a fairly rapid assessment which would give a damage estimate which could not be obtained in any other way. We believe the method outlined below accomplished this, providing a quantitative value of existing damage.

The first thing done was to measure in millimeters the length occupied by ten consecutive kernels in three different rows, one at the tip of the ear, one at the middle, and one at the base at different points around the ear. Then the sum of the widths of each kernel in the ten was obtained and averaged. This was multiplied by the average thickness, along the row, of the kernels to give the area of an average kernel in each ten. These three areas were then averaged to provide an average kernel area for the entire ear. All measurements were made as if each kernel were a rectangle meeting the ones of the next row at the midline between rows. The length of the filled portion of the ear was then measured and the diameter at the midpoint (to compensate for the taper of the ear) was taken; the surface area of the ear was then calculated as if it were a cylinder.

Next the damaged or missing kernels were counted, and classified as damaged by bird, mold , insect preharvest, or insect postharvest activity. There is usually some overlap in insect and mold damaged kernels, so the sum of these two exceeded the total number of damaged kernels. The number of damaged kernels in each category was recorded. When all the ears in the sample had been assessed, the number of grains in each category for each ear was multiplied by the average grain size for that ear, then the total area of each category was found for the entire sample. The total area of all ears in the sample was then found and used to calculate the average for each damage category.

The percent insect damage obtained by the above process was tabulated without attempting to convert to percent weight loss. Conversion could be done,

however, if a formula derived in experiments in Zambia (or a similar formula) were used. Adams and Harman(1) stated that analysis of small samples yielded the following results: for shelled grain, 1% damage = .12% weight loss; and for ears with husks on, 1% damage equals .22% weight loss.

2. Mold and Insect Damage Analyses in the Laboratory

Because of the need to assess the extent of damage by birds, rodents, and insects on ear maize samples before shelling, moisture content was not determined until after the damage assessment was completed. Since ear maize samples were sealed in plastic bags, samples which started to show moisture condensation were air dried to prevent mold development before quality assessment could be done. After the damage assessment was completed, the ears were immediately shelled and made available for the loss assessment in the laboratory.

The moisture of shelled maize, sorghum, millet and beans was determined in the field, usually at the end of each sampling day.

Each sample was sieved to remove the dockage and separate the grain from the insects as well. The clean grain was then subdivided into four sub-samples by a coning and quartering technique. One sub-sample was used for the mold and insect weight loss analysis, another for the aflatoxin assay and the remaining sub-sample (two quarters) was kept as a reference or reserve sample. A detailed procedure of the damage and loss assessment is given in Appendix Chapter III.

It was impossible to train the laboratory technicians to recognize all insect damaged grain; most of the grains identified as insect damaged had a plainly evident exit hole which is made by an emerging larva or insect. Detection of hidden insect damage is usually done by x-raying but this equipment was not available. To compensate for this, sub-samples of the grain adjudged in the laboratory as sound were examined by the entomologist. After the samples of maize and beans were tested by the laboratory personnel for dockage, insect and mold damage, and weight losses, 47 representative samples of maize which had been judged sound were taken at random and examined by the entomologist for undetected damage. This was done by splitting each grain with a pair of small, end-cut wire cutters. (The end cutters work rapidly and do not require accurate positioning of each grain as was found necessary with side or diagonal cutters.) Of the samples, hidden damage ranged from none to 90 percent with an average of 22 percent. Intensity of this damage varied from light to severe.

3. Aflatoxin Assay for Maize

A two-step procedure was followed in the determination of the extent of aflatoxin contamination of maize. The first step was accomplished by testing maize samples in the laboratory with the use of a battery-powered ultraviolet lamp. This screening process is described in detail in Appendix III.

Samples that showed bright green-yellow fluorescence (BGYF) under the ultraviolet lamp in a dark room were considered suspect for the presumptive aflatoxin test. The presumptive aflatoxin test used the Holaday Rapid screening technique. (See Appendix Chapter III for procedure.)

C. Local Participation in Project Design

The Team began its work with the development of channels of communication with governmental, institutional, donor and other agency officials who were knowledgeable and would be helpful with the tasks confronting the Team. Background information was needed which would identify work completed and underway to avoid duplication of efforts.

Initial conferences were conducted within the Ministry of Agriculture (MOA) with the Deputy Director of Agriculture (DDA) and members of the Development Planning Division, which included both the Head and the Grains Storage Engineer of the Project Preparation Section and several staff members of the marketing development section. These officials shared information, provided written materials and suggested additional sources of information and persons to contact. During these and subsequent early meetings, the purpose for contacts was always two-fold: namely, to explain the purpose of the Team's work, and to solicit cooperation and information on the subject. Meetings were arranged with Educational Institutions--University of Nairobi and Egerton College, and other MOA Divisions and Branches including National Agricultural Laboratories (NAL), Crops Production, Manpower Development, Extension Services, Land Development, Home Economics and Rural Youth, Farmer Training Centers and the Agricultural Information Center. The Agricultural Training Institutes at Embu and Bukura, National Irrigation Rice Schemes, Agricultural Crop Research Stations, and Farmer Training Center locations were visited during the field survey period. The Ministry of Cooperative Development, Central Bureau of Statistics, National Cereals and Produce Board and donor agency officials were conferred with extensively.

Through consultation with the Central Bureau of Statistics the problem of how to obtain an adequate representative sample of smallholders and how to locate those farm sites and communicate with the respondents was solved.

By the end of September, following a review of relevant literature and meetings with different officials, the Team had developed questionnaires to obtain data from smallholders and from local suppliers of construction materials and other supplies.

The assessment of problems associated with the reduction of postharvest losses, as reported in Chapter V, was derived from data from interviews with a sample of smallholders, from informal discussions with MOA personnel at all levels of operations, and of rural institutions and other agencies associated with the handling of grains and pulses.

The design of the project was contingent on the existing or potential modification of government and institutional structures, the interest of government in reducing postharvest losses and their commitment in alleviating this problem. The availability and potential for staffing of the project including the training needs for personnel, the requirements for applied or experimental research and the need for communication with and training of farmers was considered. It was necessary to develop linkages between and among all agencies participating in components of the project (described in Chapter VI).

The administrative structure of the Ministry of Agriculture warrants at least a brief description. It is more complex than the other institutions and agencies.

The Ministry of Agriculture is headed by the Director of Agriculture. Much of that Department's operations are under the jurisdiction of the Deputy Director of Agriculture who provides immediate supervision to those Branches that cooperated with the project team:

Manpower Development Branch. The Manpower Development Branch is charged with all aspects of training of Ministry of Agriculture personnel both overseas and in-country programs. This branch also coordinates the training for certificate level at the Bukura and Embu Institutes of Agriculture and for diploma level at Egerton College in Njoro.

Extension Services Branch. The Extension Services Branch is responsible for coordinating staff matters between the MOA personnel office and divisions and the provincial extension offices. It is also responsible for the operation of large scale Farmers Training Centers which conduct year-long training programs.

Agricultural Information Center. The Center collects, collates and disseminates information from research institutions and other sources to the Extension Services. It also conducts training of extension personnel in the arts and techniques of communication.

Home Economics and Rural Youth Branch. The Branch addresses itself to all the problems that face the rural family as a unit. This includes child care, agricultural productivity, health and nutrition, clothing, family development and home management.

Farmers Training Centers. The Farmers Training Centers are generally charged with conducting one-week training programs for selected farmers in specific matters that relate to better agricultural productivity. There are 25 centers operated under the Ministry of Agriculture of which one center is located in every district.

The Project Management and Evaluation Division is responsible for the implementation of development projects in coordination with the other MOA Divisions and Branches.

The Crop Production Division is in charge of the production activities of industrial, food and horticultural crops. In addition the Crops Pests and Vermin Control Branch is included. Postharvest loss prevention technology is disseminated by this Division through the provincial directors of agriculture.

The Land Development Division assumes the responsibility for the Machinery, Soil and Water Conservation, and Irrigation Branches. Also, this Division provides the necessary services for the construction of grain storage and drying facilities at agricultural showgrounds in Kenya.

Under the Director of Research is included various agriculture research stations located throughout Kenya where grain, pulses and horticultural crops are produced under applied research conditions, and the National Agricultural Laboratories. The latter has been contributing to applied research findings and training in postharvest loss reduction work.

The Agricultural Programs being advocated by MOA are implemented or monitored at the Provincial, District, Divisional and Locational levels. Staff officers and personnel are posted at each of these levels where they provide administrative, program coordination and training activities in addition to their responsibilities to assist farm families.

Training opportunities at polytechnics for the teaching of storage and drying facilities construction skills were informally surveyed during the field study period. The responses of individuals conferred with indicated an ample teaching capacity and the number of graduates exceeded employment opportunities.

In summary, over 300 professional persons at different position levels with the institutions and agencies listed previously in this section and nearly 200 smallholder families were conferred with during the course of the study. A list of major contacts is shown in Table III-6.

REFERENCES

(1) Adams J.M. and Harman, G.W. The Evaluation of Losses in Maize Stored on a Selection of Small Farms in Zambia with Particular Reference to the Development of Methodology. Tropical Products Institute, U.K. Ministry of Overseas Development, London, 1977.

Table III-6. Major agencies contacted by the study team

Kenya National Crop Storage Study

The team cooperated with:

1. University of Nairobi (Degree level)*
   a. Department of Entomology
   b. Department of Botany (microbiology)
   c. Department of Agricultural Engineering
   d. Department of Agricultural Economics

2. Egerton College (Diploma level)*
   a. Department of Agricultural Engineering
   b. Department of Crop Production
   c. Department of Biology

3. Embu and Bukura Agricultural Training Institutes (Diploma level)*

4. Ministry of Agriculture
   a. Deputy Director of Agriculture*
   b. Director of Research; NAL & NHRS*
   c. Chief, Project Management and Evaluation Division**
   d. Chief, Crop Production Division*
   e. Head, Project Preparation Section**
   f. Head, Manpower Development Branch**
   g. Head, Extension Services Branch*
   h. Head, Agricultural Informaton Center*
   i. Head, Home Economics and Rural Youth Branch*
   j. Head, Farmers Training Center*
   k. Chief, Land Development Division*

5. Ministry of Cooperative Development*

6. Central Bureau of Statistics*

7. National Irrigation Board**

8. Cereals and Produce Board**

9. Other Donor Agencies,** (FAO, UNICEF, DANIDA, TPI, FISS, GAT)

10. African Diatomite Industries, Ltd.**

11. International Center of Insect Physiology and Ecology**

12. Kenya Herbarium**

13. Rentokil Laboratories, Ltd.**

14. U.S.A.I.D. Mission to Kenya**

* USAID interventions under consideration
** For liaison and consultation purposes

IV. SURVEY RESULTS AND DISCUSSION OF PRESENT POSTHARVEST GRAIN HANDLING SYSTEMS

A. Postharvest and Pre-storage Handling

1. Maize

In all areas visited, maize is left in the field for an extended drying period after maturity, often as long as 60 days. Usually the stems of the ears are broken sufficiently to make the ear hang tip downward to minimize wetting by rain during drying; this action also cuts off most of the moisture movement through normal transpiration.

In several locations, notably the Bungoma/Kitale area, maize is cut and either stacked in large shocks (3 to 4 meter diameter base) or laid on the ground in equally large piles for a period of two weeks to a month and a half. During this time, the inside of the shocks and piles frequently become wet.

After ears were picked from the stalks, two ways of handling were observed: (1) remove the husk immediately, often in the field, then dump the ears into the store; or, (2) dump the ears, unhusked, into the store. In both cases, the piles of ears in the stores are frequently so large that drying of ears inside of the pile is very slow. These conditions foster mold and insect growth.

The long post-maturity period in the field is particularly favorable for insect infestation, with both maize weevil and angoumois grain moth being able to establish populations in the drying maize and even produce two generations in grain exposed for the longer periods.

Mold also develops to a great degree as a result of the field drying conditions and the production of aflatoxin can be increased by the intermittent wetting and drying (1). Comments made by farmers and extension personnel indicate considerable rodent damage in the field.

Grain comes from the field with a serious degree of loss from the three major causes. Good evidence as to the amount of loss experienced was seen at those farms and institutions, such as FTCs, where the ears were sorted at harvest into "badly damaged", usually by mold, and "good" piles. Often the two piles were of similar proportions. The "bad" pile, however, did not represent a total loss as the maize in it was usually used as animal food or for brewing.

In only two areas, Coastal and Kitui, was artificial drying employed to any degree. In both regions smoking of maize is practical, usually with the husk left on the ear. It is believed that smoking deters insects but the greatest benefit is probably the accelerated drying rate and lower moisture content achieved.

Out of 183 respondents, 91 percent dried their maize in the field and then directly put it in cribs. The remainder of the respondents dry on the ground (2%), on mats (4%), and on a rack or platform (3%). No respondent ever indicated that maize is dried in the crib indicating their belief that maize is fully dry when cribbed.

The result of the study shows also that the supposedly "dry" maize, after field drying, is not dry enough for long term storage. Table IV-1 shows that the average moisture of recently harvested maize was 19.14 percent, a level which will cause rapid molding. The table also shows that grain moisture drops to below 13 percent after 3 months in storage.

The most important improvements in the postharvest handling of maize would be (1) harvesting the maize as it becomes mature without drying in the field, (2) removing the husks immediately so more rapid moisture loss can be achieved, (3) sundrying husked ears on ventilated platforms such as those used for drying pyrethrum or coffee, (4) using cribs of better design (narrower with double walls with openings sufficient to allow good air circulation) to keep the maize dryer when it is stored, and (5) proper insect treatment with approved chemicals when needed.

2. Beans

Beans are normally dried in the field to a degree just short of shattering. The entire plants then are pulled and stacked in a crib or other enclosure until drying is complete enough to allow threshing. The plants are then placed on a threshing cloth (or floor) and beaten with sticks. The coarser vines and pod fragments are picked off during the beating process and the pile of beans and small fragments is winnowed. If additional drying is needed, it is usually done on a cloth, mat or plastic sheet on the ground under the sun. Table IV-2 shows drying methods used. After winnowing, the beans are put into bags or other containers which are stored in the house or crib. Insecticides are used 37 percent of the time but examination of the samples showed 51.5 percent to be infested with the bean weevil.

Threshing is the major operation which could be improved as the rough-handling involved produces many broken beans. Earlier harvest, rapid drying and better use of approved insecticides would be other means of reducing the losses.

B. On-farm Grain Storage

The study team conducted a formal survey of the current grain storage practices in 5 major maize producing provinces of Kenya and an informal survey in 1 province.

Table IV-1. Average moisture content of shelled maize samples

Period after harvest	Percent moisture content (w.b.)
0-1 week	19.14
1 week to 1 month	15.50
2 months	13.95
3 months	12.64
4 months	12.32
⋮	⋮
6 months	12.15
10 months	12.01
11 months	11.52

Table IV-2. Method of drying beans, percent

Province	In field*	On ground	On mats
Nyanza	100.0	--	--
Western	68.4	31.5	--
Rift Valley	82.6	8.7	8.7
Central	78.5	14.3	7.1
Eastern	93.3	6.6	--
TOTAL	82.9	13.4	3.6

* Implies no other drying method is used after field drying is completed.

1. Form of Storing Grains

a. Maize

The majority of the farmers stored their maize in ear form, with the husk removed (Table IV-3).

b. Beans

Because of the relative importance of beans in the diets of Kenyans, and their higher price, they receive more care than other grains and are usually stored in shelled form. Pulses, like cowpeas, are stored either in the pod or shelled form.

c. Sorghum

Grain sorghum is usually stored in the heads and threshed whenever they are needed. The heads are stored in structures similar to a maize crib. In most farms, the heads are stored loosely like ear maize in a mud plastered crib. The mixed storage of sorghum heads with ear maize in a crib was found to be an unsound practice; there was a very high degree of insect infestation.

d. Millet

Two general types of millets were encountered in the survey, common spike-type and finger-like millet. The former is usually threshed after drying and stored in small containers such as gourds, cans or woven baskets. Finger millet is usually stored just like grain sorghum--in the heads.

2. Type of Storage Facilities

The storage facilities used are, in general, designed for storing maize. Other food crops such as sorghum, millet, beans and pulses are also stored, together with maize, in whatever storage facilities are owned by the farmer. Table IV-4 shows types of storages used by district.

3. Types and Shapes of Maize Cribs

The team recorded crib configurations, sizes, materials of construction, and whether they are plastered with mud (inside, outside or both sides). In Table IV-5, it can be seen that 62 percent of the farmers' cribs were rectangular in shape, 17 percent were circular, 20 percent were of the elevated wicker-type basket and 1 percent were conical. Materials of construction were a combination of wood poles, sisal poles (flower stem), round or split bamboo, sticks, and plant stalks. By and large, wood poles are used for structural support of the crib and the other materials are used for either the floor or the wall. Mudded walls were used on 23 percent of the cribs. Figures IV-1 to IV-5 show typical maize cribs found in the survey.

Table IV-3. Maize: form of storage by province, percent

Province	Ear with husk	Ear without husk	Shelled
	(%)	(%)	(%)
Nyanza	0	100	0
Western	0	86	14
Rift Valley	0	100	0
Central	4	80	16
Eastern	17	50	33
TOTAL	4	85	11

Note: Some farmers stored maize in more than one form. In such cases, only the major form of storage was recorded.

Table IV-4. Type of storage for maize

Type of storage	Percent of use	Districts where practiced, in order of importance
Storage crib	86.7	ALL DISTRICTS
Racks inside dwelling	4.8	Kirinyaga, Uasin-Gishu, Nandi, Trans-Nzoia
Hanging on crossbeam inside dwelling	1.6	Murang'a
In dwelling, other	3.2	Uasin-Gishu, Bungoma, Trans-Nzoia, Murang'a
Hanging in tree or rack outside dwelling	2.7	Embu, Meru
Farmers building crib at time of visit	1.1	Nakuru, Machakos

Note: A few farmers utilized more than one form of storage, in which case, only the major form of storage was recorded.

Table IV-5. Types of cribs and materials of construction
(No. of farmers using each type of crib)

Type of crib and materials	Percent of type	Type, percent of total	District where found, in order of importance (CAPITALS indicate most common types in this district)
Elevated basket		20	
Woven sticks	82		S. NYANZA, KISII, KAKAMEGA, Bungoma, Murang'a, Embu
Papyrus	15		S. Nyanza
Plant stalks	3		S. Nyanza, Machakos
Mudded	62		
Rectangular crib		62	
Round pole wood walls	43		NANDI, TRANS-NZOIA, KIRINYAGA, Kakamega, UASIN-GISHU, Kericho, Kisii, Nakuru, Meru, Murang'a, Machakos
Sawn wood walls	19		KERICHO, Nakuru, Kakamega, Meru, Kisii, Murang'a
Sisal pole walls	14		BUNGOMA, Nandi, Kissii, Kirinyaga, Embu
Log cabin sisal	7		MACHAKOS
Woven sticks			Embu, Trans-Nzoia, Kirinyaga, Machakos
Bamboo	7		Nakuru, Uasin-Gishu, Trans-Nzoia
Plant stalks	3		Bungoma, Uasin-Gishu, Trans-Nzoia
Wire mesh	1		Nandi
Mudded	8		
Circular crib		17	
Woven sticks	61		EMBU, MURANG'A, MERU, Machakos, Nandi
Round wood	23		Kericho, Uasin-Gishu, Trans-Nzoia, Kakamega
Bamboo	14		Uasin-Gishu, Trans-Nzoia
Sisal pole walls	2		Machakos
Mudded	36		
Conical crib		1	
Thatch walls	100		Machakos
Mudded	0		

Figure IV-1. A typical crib (in Machakos district) made of sisal poles and elevated from the ground with rocks.

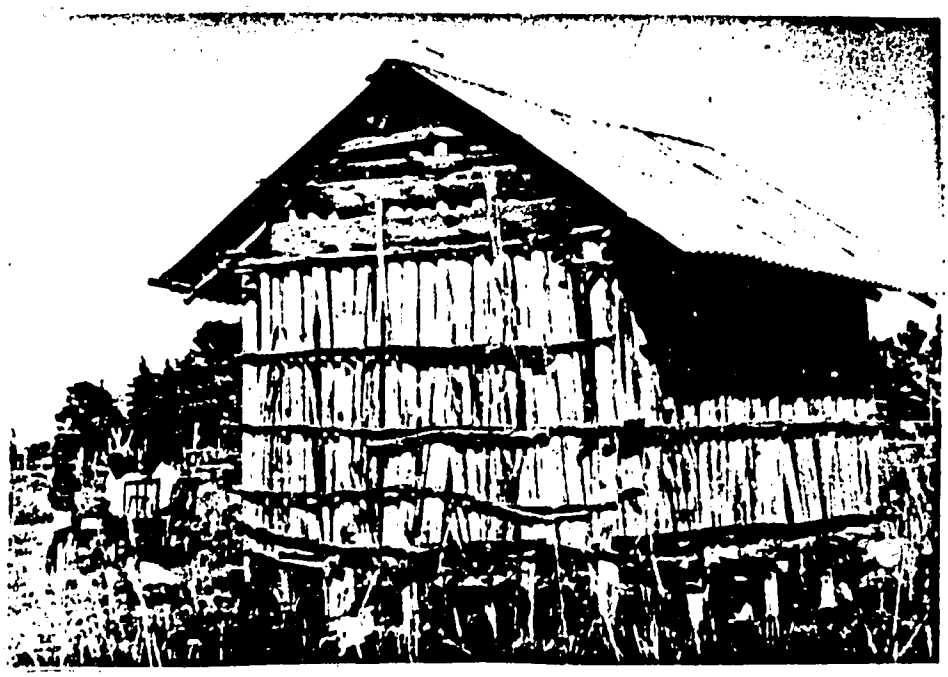

Figure IV-2. An improved grain store in Nandi district made of wood poles and galvanized iron roof.

Figure IV-3. A muddied crib found in Uasin-Gishu District.

Figure IV-4. Traditional wicker-type store typical in South Nyanza district.

Figure IV-5. Other storage facilities found in various parts of Kenya. A small grain storage basket found in Kitui district, top left; a round crib found also in Kitui, top right; a smoking house store in Kilifi district, bottom left; and hanging ear maize on trees in the districts of Meru and Embu, bottom right.

In areas where sisal is grown on large scale farms, the use of its spike or flower stem for crib construction is wide spread and practical. While sisal spikes or poles are not as structurally durable as wood poles, the material is relatively cheap, uniform in size, resistant to wood boring insects, light weight, and structurally sound for practical purposes.

Bamboo is another construction material which is readily available in many districts, such as Nakuru, Uasin-Gishu, Trans-Nzoia and in the Coast Province. The material, as round pole, is usually used for structural support; in split form, it is mostly used for floor material, walls or even roofs. Its apparent drawback, as a construction material, is its susceptibility to wood boring insects. However, some species of bamboo are known to be resistant to insect attack when cut at a certain stage of maturity.

4. Storage Capacity of Maize Cribs

The storage capacity of an average small farm holder in Kenya is well above the average maize production of 1,012 Kg, Table IV-6. The additional capacity is being utilized for storing miscellaneous articles such as small containers, hand tools, empty bags, seeds, fertilizers, etc.

Rectangular cribs, had capacities ranging from 1,555 Kg to 8,610 Kg with an average capacity of 5,790 Kg; the traditional elevated basket, mostly found in South Nyanza district, had an average capacity of 1,503 Kg. The capacity is determined largely by the durability of the construction material used and the crib shape.

5. Average Age and Expected Life of Cribs

The national average age of the cribs was found to be 5.3 years with an expected useful life of 9.7 years.

6. Type of Crib Roof

Eighty percent of the cribs studied had thatch roofs of various configurations, Table IV-7; the shape varied from conical to ridge roof depending on the shape of the crib. Approximately 20 percent had metal roofs of corrugated galvanized iron or flattened kerosene cans used as shingles. The galvanized roofing was of a relatively thin guage, #32-38, as compared to that normally used in city dwellings, #26-31. Metal roofs are seldom used on anything but rectangular cribs.

7. Construction and Cost of Stores

Because of the relatively simple construction procedure followed in the building of farm grain stores, farmers generally build their own with the help of family members. Of the farms visited, 64.4 percent built their store solely with family labor, 25.8 percent hired someone to build their store, and 9.8 percent employed both family and hired labor to build their store, Table IV-8.

Table IV-6. Capacity of cribs by type and material

Type of crib	Average capacity (Kg ear maize)
Elevated basket	1,503
Woven sticks	1,595
Papyrus	964
Plant stalks	1,755
Rectangular crib	5,790
Round wood walls	6,089
Flat wood walls	8,610
Sisal pole walls	5,391
Log cabin sisal	3,337
Woven sticks	4,070
Bamboo walls	4,990
Plant stalks	2,911
Wire mesh	1,555
Circular crib	2,609
Woven sticks	2,182
Round wood walls	3,973
Bamboo walls	3,386
Sisal pole walls	1,600
Conical crib	
Thatch walls	3,155
Average of all cribs	3,857
Average crib capacity per farmer	5,697

Table IV-7. Types of roofs of cribs, percent

District	Thatch	Metal	Bamboo
Nyanza	100	0	0
Western	85	15	0
Rift Valley	78	20	2
Central	47	53	0
Eastern	80	20	0
TOTAL	80	19.4	0.6

Table IV-8. Type of labor used in constructing cribs, percent

				Farms where labor was contributed by			
District	Family	Hired	Combined	Husband	Wife	Children	Other
Nyanza	75	10	15	80	--	56	--
Western	37	44	19	86	--	33	--
Rift Valley	80	11	8	89	13	20	24
Central	59	35	6	55	18	18	18
Eastern	50	47	3	75	12	19	31
TOTAL	64.4	25.8	9.8	100	81.8	28.9	16.5

With regards to the labor provided by the family in the construction of grain stores, approximately 82 percent of husbands, 9 percent of the wives, 29 percent of the children, and 17 percent of the other family members helped in the work; the main responsibility for construction is the husband's.

Thatch roofs for stores cost about 3.67 KSh/m^2 if purchased or require about 1.54 hours/m^2 of labor to gather. Metal roofs are much more expensive at a cost of about 20 KSh/m^2.

If materials are purchased for the walls and floors of cribs the cost is about 17 KSh/m^3 or about 4.4 hrs/m^3 of labor is required to gather materials, as shown in Table IV-9.

It requires about 5 hr/m^3 to build a crib and 1 hr/m^2 to apply the roof, Table IV-10. If labor is hired, it costs about 150 KSh to build the crib and 90 KSh to roof it.

C. Insect Control

1. Introduction

Practices for the control of storage pests encompass a variety of traditional and modern methods. Traditional insect control practices include: wood ashes liberally mixed with shelled grain; smoking of maize ears with the husk on; and lining the crib or other container with freshly pulled entire plants of a wild marigold (*Tagetes minuta L.*) (locally called Mexican marigold which, since its introduction, has become a widespread weed in East Africa).

Modern methods use several insecticides; Lindane, Malathion, DDT, Aldrin, Chlordane, and Actellic; one farmer used Phostoxin. Chemicals are usually applied as dusts, widely available in small (400 gram) perforated-top plastic containers; sprays are occasionally used.

Rodent control almost universally involves keeping cats on the premises; Warfarin was said to be used and it is widely available in Kenya as a prepared bait or a liquid concentrate used in making baits. Traps are reported to be used but the team encountered little evidence of them.

2. Discussion of Methods

Use of ashes was found in Nyanza and Eastern Provinces; judging from comments made by GOK officials the practice may be more widespread than the sampling would indicate. Table IV-11 shows insect treatment of maize. Samples of shelled maize treated with ashes, from the Kitui area, showed many moth larvae dead and shriveled in the ash; many dead maize weevil were present. No written information concerning ashes as a grain protectant has been seen but the condition and numbers of the dead moth larvae seem to indicate that the practice may have some value. Dr. C.P.F. De Lima, Chief Entomologist, National Agricultural Laboratories, Kenya, stated his belief

Table IV-9. Cribs: Cost of materials (sample sizes in parentheses)

Type of crib	Materials purchased Vol(m^3)	Materials purchased KSh/m^3	Materials gathered Vol(m^3)	Materials gathered Hours/m^3	Implicit wage KSh/hour
Rectangular crib					
Round wood walls	17.62	16.03	12.33	2.24	7.16
Flat wood walls	23.50	21.04	19.19	1.25	14.48
Sisal pole walls	11.38	9.78	9.25	3.19	3.07
Log cabin sisal	--	--	7.40	3.76	--
Bamboo walls	23.30	7.21	8.76	4.34	1.66
Woven sticks	6.50	18.93	1.00	12.00	1.58
Weighted average - rectangular cribs	17.77	16.43	11.80	2.38	6.90
Elevated basket					
Woven sticks	5.94	16.94	3.58	15.40	1.10
Circular crib					
Woven sticks	5.68	19.89	4.33	13.97	1.42
Weighted average - all cribs	13.85	16.77	9.24	4.40	4.09

Table IV-10. Time required to construct cribs

Type of crib	Roofs Hours/m^2	Cribs Hours/m^3
Rectangular crib		
Round pole wood walls	0.8	4.6
Sawn wood walls	0.6	2.6
Sisal pole walls	1.4	4.9
Log cabin sisal	1.3	3.5
Bamboo walls	1.0	9.0
Woven sticks	0.5	4.0
Weighted average - rectangular crib	0.9	4.2
Elevated basket		
Woven sticks	2.0	14.6
Circular crib		
Woven sticks	0.8	7.9
Weighted average - all cribs	1.0	5.2

Table IV-11. Insect treatment of maize by province, percent

Province	Treated	How treated		With what treated					
		Dusted	Sprayed	Don't know	Ashes	Mala-thion	Lin-dane	DDT	Phos-toxin
Nyanza	26	83	17	66	34				
Western	28	87	13	62			25		12
Rift Valley	24	87	13	67		26	7		
Central	61	69	31	81				19	
Eastern	69	88	12	36	32	27		18	
TOTAL	40	83	17	57	13	14	4	10	1

that the ash is merely a physical barrier, denying ready access to the grain. The dessicated condition of the larva indicates it to be more than that. This aspect should be investigated to a greater degree. The maize in the samples examined was damaged, some of it seriously, but this could very likely be due to post-maturity field infestation as all the larvae seen were mature (in the last instar of larval development) and no live or young larvae were found.

Smoking is used principally in the Eastern and Coast Provinces. Smoking does not appear to be effective in reducing insect attack; samples from the Kilifi district contained some of the most completely destroyed maize seen in the entire survey.

Chemical protection of grain is not yet widely practiced. Only 40.2 percent of the respondents to the questionnaire said they treated their maize with a protectant, including ashes; of these, 23 percent admitted they didn't know what they had used. They merely bought and applied the packaged material recommended by the Kenya Farmers Association, Ltd., or other dealers. Only 27 percent of the farmers reported treatment of beans.

The protectants used with rates of application, costs, and form used are presented in Table IV-12.

A list of the insects encountered with the stored products attacked can be found in Appendix Chapter IV.

Farmers treat shelled maize more frequently than ear maize; 41 percent treated shelled maize but only about 29 percent treated ear maize.

Four problems concerning the use of insecticides need corrective action. The first is the correct application of the chemical used. In almost all places observed insecticides were applied in a most haphazard and irregular manner, with extremely heavy concentrations of the dust literally plastered over the grain in places with none in large areas between. This situation was observed even at the research and teaching institutions. Usually insects were numerous in the untreated areas. The second is the use of less than the recommended dosages "to save money."

Thirdly is the universal lack of subsequent application of insecticides after that applied when the grain is first stored, even when storage is for extended periods and insects are known to be in the grain. All three of these would foster the development of insecticide resistant insect populations.

The fourth problem is the continued use of lindane, for which approval was withdrawn in 1976. As early as 1968 Giles reported maize weevil to be showing resistance to lindane in Kenya. In spite of this, lindane still is stocked by dealers and the farmers still buy and use it, even though it is very evident that resistance is high in the maize weevil at least. Dr. De Lima told the team that a pesticide registration law is before parliament

Table IV-12. Grain protectants: application rates and costs

Protectant	Form	KSh cost/unit	Application rate	Effective life	Residue tolerance
Lindane	1% dust 2% dust	2.45/200g 63.00/25Kg	100g/90Kg shelled maize 50g/90Kg shelled maize	no longer approved	1-.5 ppm
Malathion	2% E.C. 1% dust	4.30/400g 4.30/400g	1-2gal/1,000 cu ft 50g/90Kg shelled maize	6 mon. max. under dry conditions, less under humid	8 ppm
Actellic	25% E.C.	70.00/litre	1 ltr/500 sq.m(undilute)	6-12 mon.	
Dichlorvos*	Impregnated plastic strip		1 plastic strip/30 cu.m. open space	Fumigant	2 ppm
Pyrethrins	2% dust + piperonyl butoxide		100g/90Kg shelled maize and beans	Short	3 ppm
Gardona	3% dust		50g/90Kg shelled maize in tight silos 3-6tab./ton		
Phostoxin**	3g tablets		bags underplastic 1½tab/M^3	Fumigant	No residue
D.D.T. Aldrin Chlordane	5% dust 2.5% dust	2.45/200g 4.00/400g	)These are not approved for stored products but are included)here because they were reported to have been used.)They are approved for other crop uses.		
Ashes	Dust	Free	Equal amount to shelled grain	No limit	Not applicable

* Dichlorvos (Peststrip) is useable only against flying insects and in fairly tight stores, but is very effective against adult moths.

** Phostoxin is not recommended for use by farmers because of the dangers involved for untrained persons.

now, which should help rectify this situation, as it will apparently provide for inspections and enforcement of pesticide regulations.

For the most part these problems are generated by lack of knowledge on the part of the people using the chemicals. Many times comments were made by farmers to the effect that they had not been given any information by extension workers, FTCs or dealers on the proper use of the insecticides or on the appropriateness of the ones available.

The NAL has been scheduled to teach at the FTCs, for the instruction of FTC staff and TAs, but for the past year has not been able to meet any of the schedules because of loss of staff in the Entomology Section.

Supplying the TAs with good literature on the subject should be one of the important goals of the effort to reduce storage losses on the farms. Some of this literature could be obtained from chemical companies, often free. Two excellent aids in the identification of storage pests are produced by Dentsche Gesellschaft fur Schadlings Bekampfung of Frankfurt, Federal Republic of Germany. One is a folder of color illustrations of "Principal Storage Pests" with life history, descriptive, and damage information under the pictures. The cost is KSh 10.00; this should be supplied to every TA who has to deal with storage insects and problems. The other is a 120 cm x 82 cm wall chart, again in full color, of the insects and damage; this costs KSh 65.00 and would be ideal for use at institutions.

3. Innovations in Insect Control

Dichlorvos (Peststrip, Vapona, etc.) has proven very effective in the control of flying insects, particularly moths which are difficult to control with other insecticides. While it acts as a fumigant and kills at very low concentrations it does not migrate out of cracks and tiny openings in storage enclosures to the extent the other commonly used fumigants do. For these reasons it might be used in some of the tighter storage structures to kill adult pests which occur there. However it does not penetrate well into the crevices among kernels of grain so would have to be admixed with it. A liquid preparation for such application is available. The grain would have to be aired thoroughly before use, especially if from treated airtight stores of any size. Dichlorvas might be very good in small lot airtight stores such as treated gourds by cutting the impregnated plastic strips into small pieces and putting one piece in each small container. This should be an item of research.

Research should be carried out on small quantity airtight storage using treated gourds, cement or earthenware jars, etc. Which would hold one or two week supplies of grain. This would eliminate the repeated breaking of the seal which occurs when the family withdraws grain from larger silos for their current needs, as the smaller containers would be left sealed until its entire contents were emptied at once as needed.

The entomologist conducted screening experiments on three grades of processed Diotomite and one grade of pumice from African Diotomite Industries, Ltd. The results indicate a reasonable level of insecticidal action which might be exploited since these substances are completely innocuous to humans. This is another matter for serious research. The entomologist's report on the screen is in Appendix Chapter IV.

Ashes may vary in effectiveness depending upon their source. Rice hull ashes are known to be very abrasive and should be compared to wood ashes from various species.

Two important innovations which could be introduced would be to teach farmers, and get them to practice, greatly improved sanitation of both stores and fields and to try to get them to move their stores farther from the fields, or at least out of the maize fields themselves. This latter objective will be difficult, at best, to achieve as long as the smallholders live as they do practically surrounded by their maize field. However, in many instances, the stores were some distance from the house and right on the margin of the field. The importance of separation of the store and field is emphasized by a comment made by Mr. E.J.R. Hazelden, commercial director of Kenya Seed Co. He said the company requires the farmers who grow certified seed to maintain a ½ mile wide "clean band" around seed fields. In this area no old maize, stalks, debris or granaries are allowed so back-infestation into the field before harvest, from the granaries, etc., would not occur.

Sanitation is a different matter; much could be done with this. The combination of improved sanitation, whatever separation is feasible and better insecticide application should yield worthwhile results. Sanitation practices include: removing debris from the area around the crib, removing old grain from the crib before storing new grain and cleaning and spraying the crib with an insecticide before storing new grain.

D. Rodent and Bird Losses

1. Extent of Loss

Thirty-four percent of the farmers reported rodent losses in the field and seventeen percent reported rodent losses during storage. The magnitude of the losses could not be measured by the techniques used in the loss study.

A fair estimate was made of preharvest bird losses by examining ear maize. The kernels are damaged at an immature stage but part of the kernel remains. Preharvest bird loss was estimated to be about 1.26 percent.

2. Control Measures

The farmer can do little to reduce bird losses in the field. National efforts would be required to control the responsible bird populations; control measures might be of questionable value.

Field rodent control is very difficult and probably infeasible.

Rodent control measures are effective around stores. Farmers now practice such measures; Table IV-13 shows the extent to which various control measures are used. Cats are the most common form of control but only 44 percent of the farms reported using controls. Rat guards on the supporting poles of cribs were not found.

E. Shelling, Sorting and Processing of Grain

1. Sorting of Moldy Maize

Because of the widespread practice of leaving the mature maize crop standing in the field, over a long period of time (as much as 60 days), farmers frequently harvest field-dried maize with a significant portion of the grain already damaged by mold. The majority of farmers recognize moldy grains as unfit for food. The study showed that 83 percent of the households interviewed sorted their maize prior to grinding. Farmers who sorted their grain prior to grinding disposed of the moldy grain in various ways. About 85 percent used it for animal food, 10 percent threw it away, 7 percent used it for beer making, and a few used it for manure (1 percent).

2. Shelling and Shelling Methods

The shelling process is one of the farm activities where family labor is pooled. It was found in the study that 92 percent of the housewives, 52 percent of the children, 29 percent of the husbands, and 10 percent of the relatives contributed to the shelling activity.

Table IV-13. Extent and type of rodent control, percent

Province	Farms using controls	Type of rodent control:		
		Chemical	Traps	Cat
Nyanza	53	26	7	67
Western	19	0	60	40
Rift Valley	20	35	35	43
Central	69	25	62	62
Western	68	17	34	76
Total	44	23	37	63

The method of shelling maize at the farm level has not undergone any considerable change since maize was introduced into the country. The study revealed that no mechanical device is commonly utilized at the farm level. In this study, 62 percent of the households shelled maize by beating the ears in a sack, 4 percent by beating the ears on a floor, 30 percent shell by bare hands, and 4 percent by other means. The study reveals the need to introduce inexpensive and practical shelling devices to small farm holders in Kenya. This would facilitate the shelling process so dried shelled maize could be treated with grain protectants prior to storage.

Four percent of the farms shell beans by hand, 91 percent beat with sticks on a threshing floor, and 5 percent beat beans placed in a sack. This threshing results in a large percent of broken beans.

3. Maize Milling

The preparation of maize into a form suitable for human food is done in various ways. However, at the farm level, the traditional methods of grinding with the use of mortar and pestle, hand grinder or stone grinders have been replaced by the hammer mill and 98 percent is ground by custom mills. The product is called "posho," a finely ground product which has a nutritive value similar to that of a whole maize meal. This product is nutritionally superior to sifted maize meal produced by local roller mills. Posho has a protein content of 9.3 percent as compared to only 7.9 percent for sifted flour, 7.4 percent for "pure" and 5.7 percent for "unga." Pure and unga are two forms of maize flour produced by traditional methods of degerming maize kernels prior to grinding into maize flour, Stewart (2).

F. Other Findings and Their Significance

The Integrated Rural Survey, 1974-75, reported 24 percent of small farm households headed by women; 44 percent of the respondents in this survey were women. This indicates the important role which women play in the small farm sector and the importance which must be given to formulating educational and other policies which will reach this segment.

The following data pertains largely to activities during the past year:

The role of various agencies which might play an educational role is important in planning a program to help farmers learn of better storage practices. Twenty-eight percent of our respondents have been visited by an extension agent and only 29 percent had visited an extension office; the educational program must be brought to the farmer. Farmers do respect the extension service; 91 percent expressed a desire for more help.

Local meetings, barazas, have not been well attended or are not held frequently enough; only 36 percent of study respondents attended in the past year.

The Farmer Training Centers are serving a small part of the group; only 11 percent had visited FTCs.

Radio is a valuable mass media avenue and 40 percent of the respondents own one. Evening listeners outnumber morning and noon by two to three times.

Cooperatives can serve an educational role as well as a source of farm inputs; 43 percent are cooperative members but these include many types such as purchasing cooperatives for milk or export crops. The possible role of cooperatives should be investigated further.

Only 19 percent had attended a demonstration on storage but 94 percent expressed a desire for more storage information. Farmers realize losses exist; they estimated losses at 11 percent compared to our estimate of 16 percent. Twenty percent of farmers reported that they had sold grain at harvest because of storage difficulties. Presumably, farmers have a motivation to reduce these losses--in fact, 92 percent expressed an interest in improvement of stores.

Farmers would be interested in loans to improve storage; 86 percent would be interested in credit to build new stores and 63 percent would like credit to buy insecticides. Only 21 percent were interested in credit to repair or improve present stores; this is evidently considered a minor cost item. Only 36 percent expressed an interest in drying facility credit; this probably reflects a lack of knowledge of the value of improved drying methods.

Cooperatives do not play a major role in extending credit to this group; only 11 percent had received loans from the government or cooperatives, although cooperatives are the only official government agency for extending credit to smallholders. Official credit is not reaching many smallholders.

In addition to the formal survey conducted by the team at the farm level, a series of informal discussions were conducted at various provincial and district offices and research stations of the Ministry of Agriculture to determine their present role in promoting grain productivity and food preservation. Other agencies, private sectors, and institutions were also visited, such as cooperative unions, cooperative societies, National Cereal and Produce Board Depots, agricultural schools and training centers, and local markets. Those visits were aimed at gathering relevant information on aspects of grain production, storage and processing techniques, and marketing. As a result of these informal discussions, the team arrived at a common view of the pressing needs to alleviate the present problems of the country. These needs are the following:

(1) Training of personnel. It is widely recognized by provincial and district officers of the MOA that their extension efforts, with respect to disseminating improved grain handling and storage techniques, are hampered by lack of trained personnel. The same view

was expressed by cooperative managers, principals of agricultural institutions and training centers. Past efforts by the MOA to conduct regional workshops and seminars on improved grain handling and storage techniques have drastically been reduced. At present, any planned seminar depends entirely on the initiatives of provincial or district officers and/or principals of agricultural institutes and FTCs. Some MOA officials think that the defunct mobile training team from NAL which used to conduct regional seminars and workshops should be revitalized to meet the expanding training needs of the agricultural extension service.

(2) Research activity. Traditionally, emphasis has always been placed on research efforts directed towards greater productivity. This is understandable in a country such as Kenya where there is a continuous struggle to produce enough food for its people. However, agricultural researchers in Kenya are increasingly recognizing the need to study various ways of reducing needless food losses occuring within the food production consumption chain. A specific example is in the reduction of grain loss due to insect and mold damage in the field. Another case is the potential for use of wood ashes and vegetable oils as grain protectants while in storage.

(3) Extension efforts. To facilitate the transfer of an innovation to the farmers, it was generally suggested that demonstration units should be placed not only on showgrounds but also, more importantly, on sites close to the farms. MOA officials recognize that the common idea of placing a demonstration unit at a farm level has potential. Its pitfalls, however, should not be overlooked: the process of selecting farm sites for demonstration purposes usually presents a social problem. For this reason, it was suggested that a saturation approach be adapted rather than the isolated demonstration site approach.

Other constraints noted by extension officials and field staff are the chronic shortages of printed materials that can easily convey a message and the large areas the staff has to cover, and, consequently, the need for transport facilities. The use of motorbikes, bicycles or even riding animals were viewed as alternative solutions to the transportation problem.

(4) Grain transport capability. The moving of grain from the producing to the consuming areas of the country during harvest is considered by most MOA provincial officials as a chronic problem. It is generally believed that government grain storage facilities are not sufficiently adequate or flexible to absorb peak inflow of grain. This leads to the concept of encouraging farmers to store more grains on their farms. The bad conditions of the roads during rainy days or the lack of feeder roads is recognized by many as adversely affecting grain movement at harvest in many parts of the country.

(5) Educational thrust. Presently a degree level (4-year course) in agriculture is offered only at the University of Nairobi; a diploma in agriculture (3-year course) is offered at Egerton College in Njoro and

a certificate of agriculture (2-year course) can be earned at the Institutes of Agriculture at Bukura and Embu. These institutions of learning are experiencing the lack of well-trained teaching staff in grain postharvest handling and storage. They are also encountering the problem of staff recruitment. Consequently, some positions remain unfilled, and others are being occupied by expatriates, pending the availability of a qualified national.

(6) Lending institutions and cooperative movement. There seems to be a common agreement among various sectors that there is an adequate source of funds for development work in Kenya. This belief is shared by ranking officials of MOA, FISS, FAO, MOCD, and DANIDA. It is further believed that past experiences in farm loan programs in Kenya were far from being considered successful. Repayment history is poor which suggests careful planning and implementation of future loan programs.

(7) Other findings. The study revealed a fallacy in the common belief that a majority of small farm holders sell maize immediately after harvest and then later buy back for home needs. Only 8 percent of the study respondents sold then repurchased maize, Table IV-14. The study further revealed that only 40 percent sold maize and 29 percent bought maize for home use. Of those who bought maize, 44 percent purchased their grain from fellow farmers and 58 percent bought it from traders.

Table IV-14. Buying and selling practices of smallholders.

Activity	Province, percent					Percent of total surveys
	Central	Rift Valley	Western	Nyanza	Eastern	
1. Percent who sell maize	37.0	37.7	46.4	28.6	52.8	40.4
2. Percent who bought maize	18.5	40.6	32.1	21.4	19.4	29.3
3. Percent who bought and sold maize	3.7	10.1	14.3	7.1	2.8	8.0
4. Of those who bought maize:						100.0
a) Percent who bought from other farmers	20.0	57.1	55.6	0	28.6	43.6
b) Percent who bought from traders	60.0	46.4	44.4	100.0	57.1	58.4

G. Losses Over Time

1. Maize Losses

Insect losses increase with time as populations multiply. The rate of population increase in grain which has not been treated with an insecticide is a direct function of temperature (up to the lethal limit) and moisture. Temperature conditions in Kenya are very near the optimum for insects and the humidity in major grain producing areas is high enough to encourage rapid insect development.

Table IV-15 shows observed insect losses over time for the maize samples collected from farms. It also shows a predicted loss obtained by fitting the data with an exponential curve of the form.

$$L = A \exp(BT)$$

where:

A = Constant
B = Constant
L = Loss, %
T = Time, months

The curve for the pooled (ear plus shelled maize) data is:

$$L = 0.7389 \exp(.3436\ T)$$

Drying maize to a safe level of 13 percent takes a very long time when the crop is left standing in the field or placed in a maize crib relying entirely on ambient air to dry the grain. Because both methods are practiced extensively, mold losses are high. Table IV-16 shows the mold damage found in maize. Two methods of determining mold on ear corn were used (see III-B). The results show much higher mold levels by inspection, Table IV-15; this is probably due to the fact that very moldy or highly insect damaged kernels disintegrate into a powder during shelling and the laboratory technique was unable to identify separate kernels. For analysis here the lower, laboratory, data was used.

The data shows an apparent decrease in mold damage after three months in storage. This obviously is a fallacy and is probably due to hand picking moldy ears for use as animal feed.

In addition to weight losses caused by insects and molds, quality losses can also occur. Some insects feed preferentially on the germ and there may be a significant loss of protein. Molds can, under certain conditions, produce toxic compounds; the most widespread toxin is aflatoxin which is produced by aspergillus flavus.

The same climatic conditions enhancing the production of maize enhance the development of the fungus aspergillus flavus which grows at a minimum

Table IV-15. Observed and predicted weight loss due to insects in stored maize at small farm-holders

Month	Ear maize observed loss	Shelled maize observed loss	Predicted loss
	(%)	(%)	(%)
0-1	0.39	1.02	1.04
1-2	2.96	0.85	1.47
2-3	2.81	1.42	2.07
3-4	7.35	3.86	2.92
4-5	3.39	--	4.12
5-6	--	--	5.81
6-7	--	--	8.19
7-8	--	--	11.54
8-9	12.49	22.00	16.28
9-10	--	--	22.95
10-11	--	--	32.36
11-12	34.01	--	46.63

Table IV-16. Mold damage in smallholder maize, percent

Month	Ear, laboratory	By inspection	Shelled laboratory	Total laboratory
Harvest--				
1 week	6.44		2.96	5.52
1 week-1 month	12.59	23.40 1/	6.04	9.63
1-2 months	11.33	17.26	12.66	11.70
2-3 months	8.42	21.49	7.28	8.11
3-4 months	10.82	21.01	8.39	9.95
4-5 months	5.10	5.88	1.40	4.76
5-6 months	4.52	3.72	---	4.52
6-7 months	4.57	---	---	4.57
7-8 months	11.06	2.50	27.73	15.23
8-9 months	2.41	29.00	4.75	4.25
9-10 months	1.78	10.35	2.57	2.04
10-12 months	4.75	4.17	29.81	11.58

1/ Harvest to 1 month.

relative humidity of 18 percent and at a temperature of 20°C (68°F). Molds grow favorably at a temperature range of 26°-30°C and A. flavus can develop even at 10°C. Therefore, there is hardly any maize growing area in the country where this mold will not develop. The extent of its presence would be determined largely by the favorable combination of grain moisture content and ambient temperature.

Maize samples taken from the stores of small farm holders were tested for the presence of aflatoxin. Research has demonstrated a high correlation between the presence of aflatoxin B_1 and a bright-green yellow fluorescence (BGYF) when maize is illuminated by a ultra-violet light (black light).

A random check of maize samples using the ultra-violet screening technique indicated that out of 133 households, 35 percent were suspected of having aflatoxin, and 14 percent of the entire group (40 percent of BGYF group) contained a presumptive level of 40 ppb (40 parts per billion or 40 microgram per kilogram) which is a level above the tolerance level of 20 ppb allowed for feed in interstate commerce in the USA as set by the Food and Drug Administration.

As a practical measure of aflatoxin level of contaminations, one glowing kernel per 454 grams maize sample represents about 20 ppb; 10 positive BGYF kernels per 454 grams is about 200 ppb.

Table IV-17 issued by the Florida Cooperative Extension Service of the University of Florida, USA, gives guidelines on the effect of various levels of aflatoxin taken by animals.

Table IV-17. Predicted adverse effects of aflatoxins

	Swine	Chickens	Dairy cattle	Beef cattle
	ppb	ppb	ppb	ppb
Poor performance and Stunting	200-400+	200-1000+	200+	700+
Hemorrhage and death	400+	500-1500+	700+	700+

Note: The plus (+) means aflatoxin levels above the indicated concentration.

While the aflatoxin levels adversely affecting livestock seem to be far above the presumptive level of 40 ppb found in the survey, the cumulative effect on humans continuously injecting contaminated maize may lead to their developing liver cancer. This be[illegible]s even more serious among segments of the rural population who brew loc[illegible]eer from moldy kernels of maize discarded during the sorting process. Injury to liver by aflatoxin is known to be non-reversible, Wogan (3).

Because of the seriousness of the human health problem, a concerted effort to create public awareness of the danger posed by aflatoxin-contaminated food grains deserves priority by governmental and private agencies.

Bird losses occur primarily before maize reaches maturity. Inspection of ear maize showed an estimated loss of 1.26 percent.

Rodent losses could not be determined but farmers are concerned about rodent losses. Of those interviewed, 44 percent stated that they experience such losses. Control measures used included:

Chemicals	23 percent
Traps	37 percent
Cats	63 percent

Farmers are cognizant of field damage; 71 percent reported some field damage and 19 percent reported a large amount of field damage due to rodents (36 percent) birds (70 percent) and molds (42 percent).

One hundred twenty seven respondents estimated total storage losses of 10 percent with major causes due to molds (55 percent), insects (51 percent) and rodents (23 percent). About 5 percent of the respondents reported having grain stolen.

The relationship between the various grain damage assessments as described in Chapter III-B are as follows: the percent mold damage on ear maize by surface area inspection is 1.42 times that by laboratory weighing method. Meanwhile, the insect damage on ear maize by laboratory weighing method is 1.11 times that by surface inspection.

As found in the laboratory, the percent insect damaged kernels is 4.48 times that of percent weight loss, i.e. if the percent of insect damaged kernels is divided by 4.48, it should provide a fairly accurate estimate of weight loss due to insects. This compares to a factor of 8 found by Adams and Harman (4) in Zambia.

The quality of grain samples obtained from rural markets were found to be no different from those gathered from small farm holders. This is based on 51 samples analyzed in the laboratory as compared to 188 samples from the farms. Grain samples obtained from FTCs, National Cereal and Produce Board, Research Stations and maize millers were too few to make any valid comparison.

2. Beans

Table IV-18 shows the loss due to insects and mold over time for beans stored on the farm. There is little apparent increase over time due to either factor. Beans are used rather rapidly so do not have as much opportunity for insect build-up and probably are not subject to field infestation due to the protection of the pod. It is also probable that most of the mold damage occurs in the field or while drying on the vine before threshing.

Table IV-18. Storage losses in beans, percent (58 samples)

Month	Insect loss	Mold loss	Total
0-1	0.31	6.5	6.8
1-2	0.20	4.7	4.9
2-3	0.14	3.4	3.5
3-4	0.57	5.0	5.6
4-5	0.27	4.0	4.3
5-6	0.76	4.7	5.5

3. Sorghum and Millet

Due to the limited number (18) of sorghum samples it was impossible to examine the time effects. The mold losses averaged 6 percent and insect losses 40 percent.

Seven samples of millet were collected which showed essentially no mold or insect losses.

H. Major Problem Areas and Solutions

The following changes and interventions are recommended:

- Crops should be harvested as soon after physiological maturity as possible to reduce losses which now occur before harvest, including rodent, insect and mold losses.

- Harvesting crops at the high moisture existing at the time of maturity will require new drying techniques; platform sun drying is used extensively on other crops and should be used on maize, beans, sorghum and millet.

- Grain which is to be stored for a long period, i.e., longer than three months, should be properly treated with an effective insect protectant.

- As new cribs are built, they should be narrower to provide better ventilation and equipped with rodent guards.

- Shelling and threshing losses can be reduced by improved techniques which will not damage kernels as extensively. Flailing or trampling would probably be a better technique for beans. Simple hand shellers would cause less maize breakage than occurs with the use of sticks.

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V. DISCUSSION OF STUDY FINDINGS

A. Diagnosis of the Problems and Solutions

As discussed in earlier chapters, cereal grains and pulses are the major source of food for the small farm population of Kenya. Although natural and human resources are better than in many countries, the dietary intake of most Kenyans is just slightly above minimum nutritional requirements. Short periods of adverse weather conditions can quickly lead to food deficits.

Small farmers who with their families constitute about 73 percent of the population feed themselves, and the surplus from these farms contributes about 55 percent of the marketable surplus; for the forseeable future, these small farmers are the key to survival for themselves and much of the urban population. As urban population grows the national problem of food will grow and become more acute.

Obviously the Government of Kenya has long been aware of these problems and sustained and effective efforts have been made to increase agricultural production. As in most countries these first efforts have been devoted to increasing production but as major improvements such as the use of fertilizer and hybrid seed become widespread production improvements increase more slowly and frequently become more costly. However, it is possible to increase the amount of food available at any level of production by reducing losses and the net effect is equivalent to increasing production.

Chapter IV described the existing problems and constraints which contribute to grain losses and the magnitude of the losses as determined by observation and laboratory analysis. Losses are significant for all the major grains and pulses. It is also shown that farmers are aware of the losses but probably underestimate the magnitude. However, farmer estimates of losses are high enough that solutions can be instituted before an extensive awareness campaign is begun.

Results of the survey show that major losses occur due to molds which develop in the field during the period from physiological maturity to harvest and continue to develop after harvest when the grain is stored at a high moisture content. Eventually the grain does become dry enough (after about three months) that molds cease to be a major problem.

The other major cause of loss is due to insects. Farmers recognize the problem and a large number (40 percent) do use insect protectant treatments. Unfortunately the treatment of mold problems, with the required exposure to air for drying, permits the maximum exposure to insects. When maize is stored in the ear it is very difficult to effectively apply an insecticide.

Of the losses identified, bird losses are significant. Most of this loss occurs before maturity by birds which attack ears not covered by the husk or which open the husk slightly.

Rodent losses were difficult to quantify in a survey of this type. Further testing which requires weighing grain in and out of the cribs would be necessary.

Effective proven techniques for reducing grain losses at the farm level where climatic conditions are similar to Kenya's are developing slowly. Many attempts to introduce improvements have failed due to a too high level of technology and/or too high an investment cost. It is now believed that improvements in storage must incorporate the following concepts.

1. The level of technology to be introduced should require a minimal change in existing local practices. Evolutionary rather than revolutionary changes are most desirable.

2. Proposed changes should be compatible with the availability of local materials and craft skills.

3. Any proposed changes should not seriously endanger the food supply of a family if some step of the process is not executed properly.

4. Proposed changes should be economically justifiable and have a high rate of return. The farmer should be able to see clearly that he has received a significant economic benefit.

5. Cash costs must be within the income constraints of small farmers.

B. Requisite Innovations

1. Farm Level

Based upon measured losses, magnitude of losses and other factors, certain changes in facilities and practices can be recommended for immediate adoption. These changes conform to the criteria listed in Section A.

a. Earlier harvest is recommended to reduce the large amount of mold (5.5 percent) and insect loss (0.6 percent) which occurs between physiological maturity and the present normal harvest date. This change in cultural practice must be accompanied by the improved drying techniques discussed in the next item. There is generally a period of about four to eight weeks between the time maize is mature at about 35 percent moisture and the time when it dries to below about 20 percent moisture when it is presently harvested. During this time molds develop rapidly and stored grain insects begin to infest the grain.

It is believed that this change in practice will not be too difficult to introduce. Many farmers now begin to harvest small quantities of grain at about the time of maturity for immediate household use if supplies of older grain are exhausted. Also, harvesting earlier will provide more time to prepare for the next planting; this is a particular problem in regions which normally produce two crops per year.

b. Dry immediately to a safe storage moisture. This step will require an additional facility input--a simple drying platform. Elevating wet ears to provide air circulation on all sides while the ears are exposed to the sun will provide very rapid drying. No rigorous research or testing has been carried out but limited observations indicated a time of three days from harvesting to drying to about 15 percent moisture where the maize could be safely stored in existing cribs or shelled.

   If the maize is shelled at this point (15 percent moisture) then it will need about one more day of sun drying on a mat on the platform to reduce the moisture to about 13 percent where it could be safely stored in insect proof containers after treating with insecticide.

c. Shelling all or a part of the maize is recommended to enable more effective insect treatment to be carried out and/or allow grain to be stored in insect resistant containers. It is very difficult to apply dust type insecticides to ear maize and cover all of the surface.

   Maize which is not shelled but is properly dried can be stored in the traditional existing cribs and if consumed fairly soon (2-3 months) little insect loss will occur. Grain to be stored for longer periods will incur much less insect loss if shelled and treated.

d. Grain to be stored for longer periods should be treated for insect control. Ashes are one widespread traditional treatment which appears, from samples collected, to be of value. Chemicals such as malathion or actelic would be more effective. Preliminary studies by the team entomologist indicated that diatomite and blue pumice which are locally available would be very effective if properly used. With one of the best possible treatments properly applied, insect losses should be practically eliminated.

   Farmers are aware of the value of insect protectants. They are used by a large number of farmers and the distribution system for protectants is well developed. Forty percent of the farmers interviewed were using insect treatment.

e. Containers will be required for shelled treated grain. Gunny bags are readily available and will be adequate for most of the grain. In regions which have one harvest per year consideration should be given to using insect resistant containers. Gourds and ceramic jars are presently used; larger concrete containers might be useful.

f. Stores should be well designed for their intended use. Most existing stores use large amounts of locally available materials, wood, thatch, etc., and this is to be commended. Many of the stores used presently for drying are too wide and mold damage is high. Plastered stores also inhibit drying.

   For maize to be dried on the ear, farmers should be encouraged to construct stores of no more than 1½ meter width (or 1½ meter diameter if round).

   The structure type for storage of containers is less critical. It should protect the containers from being directly wetted by rain either through the roof or sidewalls.

   The storage structure should provide for protection from rodents and birds.

g. Quality maintenance is important in any grain storage system. Grain should be inspected routinely to ascertain that the quality is being maintained; this is particularly true with respect to insect and mold damage.

   Evidence of deteriorating quality would lead to remedial measures such as redrying or retreating.

2. Off-Farm Level

Off-farm level measures will be necessary to promote the rapid adoption of farm practice changes. These off-farm inputs will be more of an educational nature than physical inputs.

Kenya has a well developed program for farmer education and training through avenues such as the extension service and farmer training centers. Extensive interviews with personnel indicated an interest in reduction of grain losses but a lack of supportive training of the lower echelons of persons who are in direct contact with farmers. This need for training backs up through the entire system for training persons working in the agricultural education field. We therefore must build a structure for the training of trainers--manpower development.

The next chapter deals in detail with the various phases of manpower development. Starting at the top, inputs to the National University in Nairobi are needed. Basically the needs consist of the provision of expatriate faculty as an interim measure until permanent Kenyan faculty can be trained abroad.

The two and three year institutions, Egerton, Embu, and Bukura, have much of the basic faculty expertise and facilities to institute an effective training program related to loss reduction. Some expatriate assistance will be required while faculty are trained abroad. After the faculty development program is in operation at the University, faculty for the three agricultural institutions could be trained in-country at the University.

Training of manpower to work in the very near future with various FTC and extension personnel is a critical problem. Some of the trainers can be trained in the U.S. or the U.K. at existing short courses and with limited in-country supplemental training.

All of the above training activities will require some facilities, equipment, and materials.

Research and testing programs are foreseen in several areas which include:

(1) Seed breeding to develop varieties more resistant to major losses--mold and insects.

(2) Continued development or improvement in harvesting, shelling, threshing and similar processes. These developments should be related to both efficiency and loss reduction.

(3) Testing the use and efficiency of non-chemical insecticides. This program may lead to more use of indigenous products with a resultant saving in foreign exchange.

(4) Improvement in facility and equipment design and use. This would include drying platforms, simple heated dryers, cribs, and containers.

(5) Field testing of new equipment and practices, e.g., dusting equipment.

(6) Methods of detoxifying aflatoxin-contaminated grain.

During the course of research and testing programs it is highly recommended that the technical research person be joined by an experienced extension person. This recommendation if followed will have two major advantages:

(1) The ideas and methods tested will have a greater chance of success (adoption) in the field.

(2) The extension person will be in a better position to incorporate new developments into the field programs.

Many research developments which succeed in the laboratory or under controlled conditions fail when applied in the field. It is proposed that a field testing program be developed to evaluate new developments under practical farm conditions. This program will also provide more background data, over a longer period, of existing losses than this team could do in a few months.

In order to focus attention on the grain loss prevention program, it is recommended that the Ministry of Agriculture set up an appropriate agency to coordinate activities in this field and to lend technical support to other groups within and outside the MOA.

Several other GOK agencies are in a position to lend major support to this program. The mass media, particularly radio, should aid in creating an awareness of the need for grain loss reductions as well as disseminating information regarding actions which the individual farmer may take to reduce losses.

An extensive program to introduce new concepts is proposed. This will include demonstration units at colleges and FTCs but also proposes a massive program designed to distribute subsidized improved facilities throughout the rural areas on demonstration farms.

Figure V-1 shows the project components and their relationships to benefits at various levels within Kenya. Project component inputs are at many levels throughout the government and educational institutions, as well as directly to farmers. This multilevel approach is required because of the limited activity to date in this subject area.

3. Constraints

a. USAID

USAID has proposed that a funding level of five to seven million dollars be established for this project. This level appears to be adequate to establish a viable program with sufficient support to achieve the objectives outlined. It will be a unique program for AID in the magnitude of funds directly aimed at reducing farm level grain losses; previous AID programs related to grain storage, and of a similar level of support, have been directed to off-farm grain storage.

Major efforts of the project which impact directly with and on farmers are concentrated in the two provinces where AID is now directing major efforts. Other supporting components of the project provide basic foundations from which a national program can and should be developed. Some of the components will have overall national impact:

(1) Extension workers trained at the colleges who receive training on loss reduction will be employed throughout the country.

(2) Mass media campaigns, particularly radio, will reach farmers nationwide.

b. Government of Kenya

The Government is limited in resources which it can devote to any particular development project. This project has recognized this constraint and attempted to integrate as much of the work as possible with other ongoing activities. Wherever possible existing agencies were consulted first regarding their interest in the subject area, their existing activities, and finally their capability for adding one additional component to present activities.

This has received enthusiastic support from the agencies which will be involved in various phases of the project and in almost all cases two or more meetings were held with the agencies to develop program details. There has been universal agreement that the subject of grain losses is a neglected area.

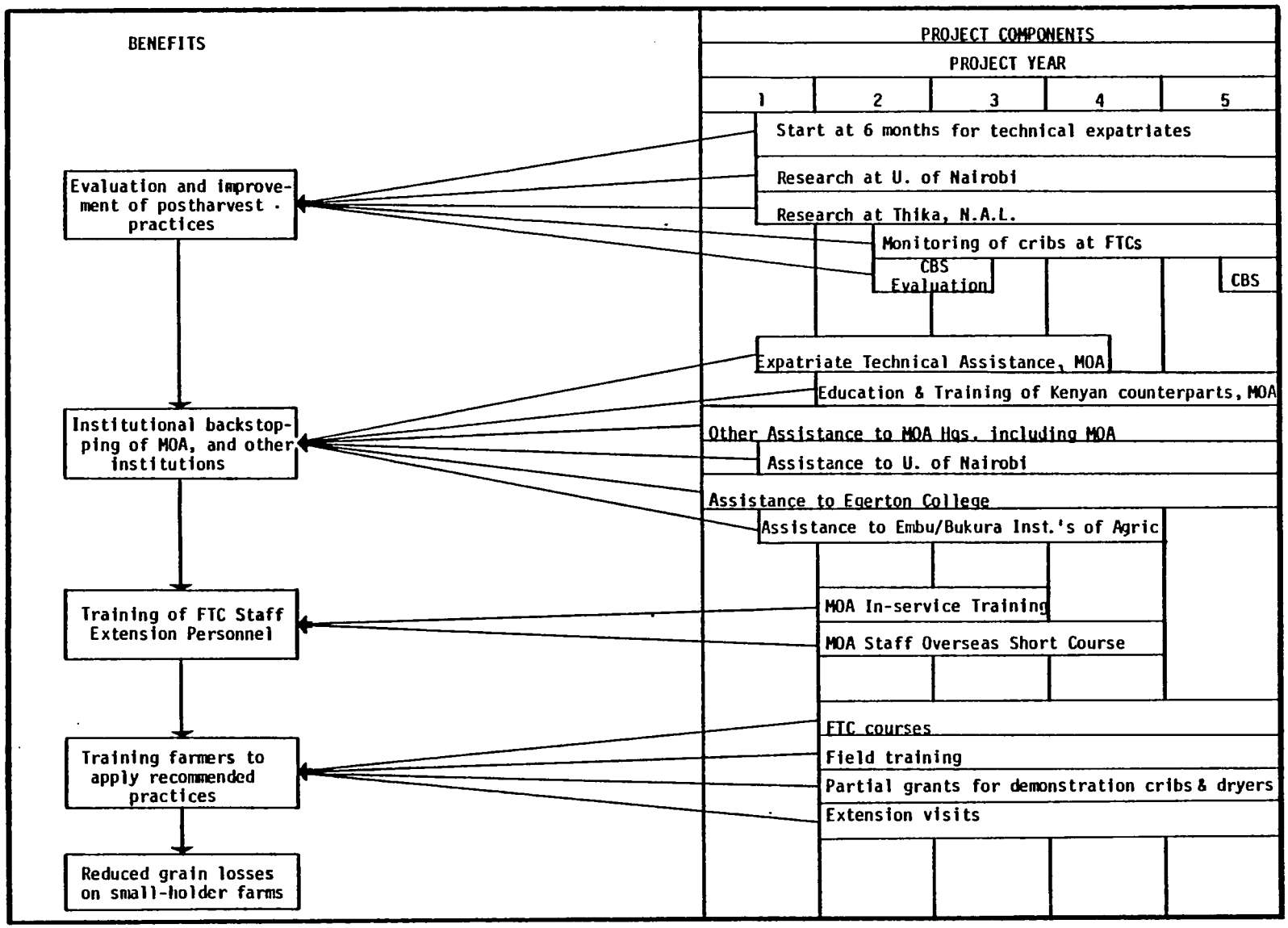

Figure V-1. Schematic diagram of project components and anticipated benefits

C. Village Level Stores

1. Food Storage Facilities

At the present time, the Ministry of Cooperative Development is in the process of building storage facilities at cooperative unions and societies. These come in two sizes--2,000 and 6,000 bag capacity. The floors are made of reinforced concrete, the walls of reinforced concrete blocks, and the roofs of galvanized iron sheets. The smaller size costs KSh 75,000 or 37.50 per bag of storage capacity; the larger costs KSh 207,000 or 34.50 per bag. At present, there are 44 stores already built or being built, primarily in Nyanza, Western, and Eastern Provinces, and there are plans for 33 more stores. For the most part, these are being financed by IADP and SPSCP programs, although 17 of the future 33 stores will be financed by the EEC.

The members of the cooperative (coop) societies are smallholders. In theory, these stores can perform two not mutually exclusive functions for the members. First of all, they can serve as collection centers for surplus production of smallholders at one stage of the marketing system on the way to final consumption by consumers. This is their primary function at present. Secondly, these stores could provide medium- to long-term storage facilities for resale and treatment. They are also being used to stock production inputs to sell to farmers on credit or otherwise. This is a new concept in grain storage in Kenya. Each of these roles is discussed below. The discussion here of the two roles is from society's point of view. That in Section VI. D. is from the coop point of view.

a. Cooperative Stores as Collection Centers

At present, about 8 percent of marketed smallholder production of maize is handled by cooperatives(1). This represents an alternative to marketing through market traders, lorry traders, or the National Cereals and Produce Board or direct sales to the consumer. Cooperatives that market grain, collecting surplus smallholder production in their stores and moving the grain up the marketing system, provide a service and add value to the product. However, many cooperatives have had to use stores not well designed for grain storage. It is a role that the team has no difficulty recommending that the cooperatives should expand, although the rate and extent of expansion might be disputed.

There have been many reports and documents, including the 1979-83 Development Plan, that have decried the inefficiencies in the present marketing system for maize and beans(2). An expanded role for cooperatives, say, until they captured 25 percent of the market, would provide more competition, increase efficiency, and, especially if the cooperatives are able to reduce existing marketing margins, benefit the smallholders who are their members.

One report has projected that the amounts of maize and beans handled by the cooperatives will expand 11.7 percent per year over the period 1979 to 1983(3). Certainly their role will expand if only because some cooperatives are

purchasing maize and beans as a means of collecting on production credit given under the IADP and SPSCP programs, but the rate of expansion is unlikely to be this great. This is especially true considering the reduction in the smallholder production of maize in the 1979-80 crop year. Chapter VI, Component D, presents an economic analysis of the feasibility of expanding the role of cooperatives in grain storage and marketing.

b. Cooperative Stores as Medium- to Long-Term Storage for Resale of Product to Members

With few exceptions, cooperatives do not perform this role at present in Kenya. (Only one report claims that 15 cooperative societies in Central and Eastern Province bought 1,620 metric tons of maize in 1977 for resale to members (3).) Consequently, this is a more controversial subject.

Medium- to long-term storage in cooperative stores represents an alternative to storing grain on smallholder farms, where most smallholders presently store their grain. From society's point of view, the former might be desirable if any economies of scale and reduced grain losses arising from large-scale storage outweigh the additional cost of transport from the smallholding to the cooperative store and back again. There are parts of the country (e.g., Bungoma district) where the density of population and the level of maize productivity are high enough to justify such an operation, i.e., if one hundred percent of maize producers in the vicinity belong to the cooperatives and store their entire production of maize in the cooperative store, and if the cooperative can store grain with 2.5 percent less grain loss than farmers on their smallholding. If fewer farmers participate the amount of grain loss reduction will need to be correspondingly greater.

(The following assumptions are made in this calculation. Economies of scale in capital costs are minimal. The cost of a 2,000 bag cooperative store is 37.50 per bag. The cost of an 18 bag drying and storing crib at KSh 500 to KSh 1,000 is 27.78 to 55.56 per bag. The same is assumed true of administrative costs, because of the far greater valuation placed on the time of the cooperative store manager. Average production of maize by smallholder producing maize in Bungoma district is about 16 bags a year. Therefore, 125 farmers would need to participate with their entire production to fill a 2,000 bag store. At a density of 30 farms per square kilometer, 125 farmers can be found within a radius of 1.15 kilometers or an average distance of about 1 km from the store. At an average transport cost of 1 shilling per kilometer per bag, the cooperative store must save KSh 2 per 80 bag or 2.5 percent in terms of reduced grain loss. The rough accuracy of this calculation is borne out by the fact that smallholders in overwhelming members already transport grain an average of more than one kilometer to posho mills for a saving of an equivalent magnitude.)

In its work, the team has identified critical interventions to reduce post-harvest losses in Kenya. By and large, these occur at the farm level and they include harvesting crops soon after maturity, drying crops either on platforms or in cribs of width less than or equal to 1½ meters, and correct treatment with appropriate insecticides. The major thrust of the team's recommendations concerns ways of effecting these interventions at the farm level. Medium- to long-term storage in cooperative stores for resale to

members represents an alternative approach that could, in theory, also serve to reduce postharvest losses. But the team is not willing to recommend, for a number of reasons, that cooperative stores be constructed for this purpose at this time.

First, if the cooperatives were in this way to make a significant contribution to reducing postharvest losses, then the number of stores that would need to be constructed is in the order of 1,000--enough to store about 15 percent of total smallholder production in the country. This is beyond the capacity of the cooperative movement as it presently exists in Kenya to construct the stores or to administer the large sums of capital involved in such an operation. The cooperative movement is presently concentrated on cash crops such as coffee, milk and pyrethrum and those cooperative societies which do handle maize and beans are weak institutionally to some extent because they are handling a lower-value crop. At the present time, no more than 5 percent of smallholders belong to cooperative societies that market maize and/or beans.

Secondly, the concept is totally foreign to most smallholders in Kenya and it is unlikely that they will accept it. To them, real food security is to have food stored on their own farm, not one to two kilometers away in a cooperative store. This concept of food security goes for the country as a whole as well, considering that 85 percent of the population lives on smallholder farms.

Thirdly, there is an equity argument. Smallholders are among the poorest people in Kenya. It is more equitable to promote capital investment in a large number of small storage structures on smallholder farms than in large structures at cooperative sites.

Fourthly, the concept of medium- to long-term storage of smallholder produce at cooperative sites has received absolutely no support from officials in the Ministry of Agriculture who, under the IADP and SPSCP program, would be directly involved. Reasons given echo those above. It is wrong to ask officials to implement a program in which they do not believe.

Fifthly, although some officials in the Ministry of Cooperative Development in Nairobi support the concept, the managers of cooperative unions in the field are reluctant to assume such a role because of the capital that would become tied up in stocks and because, under present laws and regulations, they have no say over the buying and selling prices of maize. Some cooperatives, simply in collecting and moving maize up the market system, have suffered economic loss for this reason. (Large quantities of financial capital would become tied up in stocks because farmers will not be willing to bring their produce to cooperative stores unless they are paid, at a minimum, the price they could receive from a market trader in a nearby market.)

2. Other Facilities

It has already been observed that cooperatives are already constructing stores as collection centers for members' produce. The team supports this

effort. However, it feels that the simple construction of stores is not sufficient. None of the cooperatives as yet have moisture meters, grain-grading equipment, or grain-drying facilities, which are an indispensable part of an efficient marketing operation. At present the National Cereals and Produce Board appears to be the only institution with such equipment. Chapter VI Component D lists grain quality equipment which would be needed.

3. Training

Once stores are constructed and equipment purchased, the managers of cooperative stores must be trained how to use them.

4. Conclusions:

(1) The emphasis of the project is on smallholders and reducing smallholder grain losses.

(2) Marketing and storage by coops is desirable and should be pursued under another project.

(3) We have written up and costed a component but not recommended it as part of this grain storage project.

D. Credit to Farmers for Grain Storage Facilities

1. Desire and Need for Credit

During the survey, farmers were asked if they would like to receive credit to build new storage facilities and to purchase insecticides. A very large majority indicated a desire for such credit. However, the interpreters' explanation of this question may have led to inaccurate responses. Many farmers may consider a loan from the government as more of a gift than a loan, and the repayment rate on loans in some past programs would tend to substantiate this idea.

The next question to be raised is how badly do farmers need loans for improved storage technology? Based upon the analysis in the next section, the actual cost required to achieve significant loss reductions is relatively small: KSh 155 for a drying platform, KSh 20 for a plastic cover and about KSh 10 for insecticides to treat 1,400 Kg of grain. The drying platform cost will generally be for labor to gather local materials and build. If materials were purchased, labor hired, and a sheet metal rather than plastic cover used the cost would increase to KSh 470.

An improved crib of the design suggested (Appendix VI) would cost about KSh 1,200 if materials were purchased and labor hired. If thatch and crib materials are gathered locally and the crib is constructed by the farmer the estimated cost is KSh 300.

The cost range for a farm for drying platform and crib will range from about KSh 450 to KSh 1,700 depending upon the amount of local labor and type of construction used.

With the recommended program of early harvest, platform drying and shelling and treating half the crop of 1,440 kg, the farmer can continue to use his existing crib until it needs replacement. This reduces the need for credit at the beginning of the program.

2. Existing Credit Institutions

Two donor-supported government programs exist to channel credit to smallholders, the SPSCP (AID supported) and the IADP (World Bank supported) programs. Two ministries are involved: Agriculture and Cooperative Development. The programs are designed to supply production credit to farmers who have less than 20 acres of land, no title deed and no official credit record. Farmers who have opposite characteristics are eligible for credit from the Agricultural Finance Corporation.

The mechanism through which credit is channeled is the Ministries of Agriculture and Cooperative Development supported by the Cooperative Bank, Cooperative Unions and Cooperative Societies. There are no other mechanisms to extend official credit to smallholders.

The programs were started in 1975 and 1976 and are still suffering from start-up difficulties. The programs are not yet implemented in all districts. Many of the societies through which loans were channeled were shells which had to be rebuilt and new societies had to be organized. The credit extended has been for production and adding a component of credit for capital investments might add to difficulties at this time.

The collection problem for capital loans may be more difficult than production loans since the repayment period would normally be over a number of years. IADP has a program wherein farmers have a cash crop which they are supposed to sell through the cooperative to insure repayment of the loan. These are frequently cash export crops where the marketing can be more tightly controlled than would be the case with maize where local marketing opportunities exist.

3. Conclusions and Recommendations

The survey showed that 65 percent of the farmers now build their own cribs with little expenditure for purchased materials. It seems safe to assume that improved cribs and drying platforms could and would be built in the same way so the cost of slightly over KSh 450 is probably a reasonable one. Farmers do rebuild their cribs about every 10 years and from their own resources, it seems reasonable to assume that they would build improved (narrower and with ratguards) cribs if they can be educated regarding the advantages of the changes.

The drying platform with plastic cover to protect grain from rain is a relatively small expense.

This analysis has led to the recommendation that funds be used for grants rather than loans. The object would be to place a large number of improved cribs and drying platforms on farms where the farmer had received good

training, at FTCs, on the use of the system. This would furnish demonstrations on the use of an improved system to supplement other educational activities. The grant program is discussed in Chapter VI, Component C.

4. Credit for Storage on Medium and Large Farms

Medium and large farmers use credit and the history of their repayment of loans is better than that of small farmers. Therefore, the team was asked to consider the possibilities of credit for commercial farmers to build storage facilities.

Because of restrictions on the movement and sale of large quantities of grain (10 or more bags) larger farmers are forced to sell to the National Cereals and Produce Board. However, the Board has a fixed price for grain purchased regardless of the time after harvest--there is no margin to cover the cost of storage. Therefore, the larger farmer has no incentive to store grain; there is no price increase over time after harvest to cover the cost of facilities, interest on inventory or losses. Unless the Board revises its pricing policies to reflect the cost of storage or unless larger farmers are permitted to transport and sell grain on open markets when prices rise seasonally there can be no economic incentive for farmers to store a large surplus.

From the standpoint of the Board it would be difficult to define a single harvest date from which storage margins would be calculated. As shown in Table II-1 grain is harvested almost continually throughout Kenya, the exception being the two summer months when little if any harvest occurs. This is unlike the situation which prevails in countries which have one distinct harvest period per year for each crop.

Therefore the study team can see no possible economic justification for medium and large farmers to store grain at the farm level. If they were free of restraints on marketing and could take advantage of local seasonal price increases they might reach a different conclusion.

E. Farm Stores From The Smallholders Viewpoint

1. General

Chapter II presents data on the amount of grain stored over time and Chapter IV shows grain losses over time. It is now possible to estimate the severity of farm grain storage losses over time.

After calculating the level of losses which now prevail, the next step is to apply interventions, in a model approach, and recalculate the probable losses under various logical intervention programs. A good analysis could be made for maize. Due to a lack of data, because of the small number of samples which could be collected, less accurate analyses could be made for beans and no attempt has been made to quantify losses for sorghum. However, the overwhelming importance of maize in diets in Kenya will indicate the important impacts of a loss reduction program.

Using the data on amount of grain in storage over time, Chapter II, Table II-6, it was possible to apply loss ratios due to birds, insects and molds, Chapter IV, Section G-1. The losses during a month were calculated by averaging the beginning and ending inventory and applying the appropriate loss factor for that period. The estimated losses under present storage conditions and practices total 16.86 percent or 2,524,000 bags as shown in Table V-1.

With basic data available it was then possible to apply different interventions to determine their effects on losses. The models evaluated included:

(1) Shell grain after crib drying, treat with an insecticide which is 75 percent effective and store in bulk containers, Table V-2.

(2) Harvest uniformly during the first month after physiological maturity, sun dry on a platform and then store in a normal crib. Here the assumption was made that one seventh of the crop would be harvested, husked and sun dried on a platform in the ear for three days. It would then be shelled and sun dried for one more day to reduce the moisture to the 14 percent range. The harvest and drying would be complete in one month after maturity compared to the present system which leaves the crop in the field for six to eight weeks after maturity. All loss reduction accrues in the field and through mold reduction while drying normally in the crib. It was assumed that field losses would be reduced 75 percent since most insect and mold loss occurs after the grain is approaching a fairly dry condition, Table V-3.

(3) Begin harvest at maturity, sun dry, shell, and treat all grain with an insecticide which is 75 percent effective. Loss reductions accrue in the field and throughout the storage period, Table V-4.

(4) Same as "3" but only one-half the grain is shelled and treated with an insecticide. The treated grain was used after the untreated grain, Table V-5. This practice would reduce shelling labor at harvest time and save some cost for insecticides.

(5) Harvest at about 25 percent moisture, about one month after maturity, crib dry in cribs about 1½ meter wide then shell and treat one-half the grain. (Tests by FAO during 1979 indicate the probable success of this practice in reducing field and storage losses.) Based upon the survey results, FAO unpublished data and estimates by the team engineers and entomologist it is estimated that field mold losses will be reduced 50 percent, storage mold losses by 50 percent because crib drying time will be reduced by over 50 percent compared to present practice, and insect losses on one-half the crop would be reduced by 75 percent, Table V-6.

Table V-1. Kenya: Estimated post harvest losses of maize on smallholdings by birds, insects, and molds, 1979

	Disposal and/or loss during period	Stored at end of period	Type of loss: Bird loss		Insect loss		Mold loss		Total loss	
	('000 bags)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)
Potential production at maturity		15,164								
	191		1.26	191.1					1.26	191.1
Actual production at maturity		14,973								
	93				.622	93.1	5.52	826.5	6.14	919.6
Actual production at time of harvest		14,880								
	2,370				.117	16.0	4.11	562.9	4.23	578.9
One month after harvest		12,510								
	2,606				.303	34.0	2.07	232.0	2.57	266.0
Two months		9,904								
	1,826				.602	54.2	0.80	71.9	1.40	126.1
Three months		8,076								
	2,159				.849	59.4			.85	59.4
Four months		5,917								
	2,291				1.198	57.1			1.20	57.1
Five months		3,626								
	1,416				1.689	49.3			1.69	49.3
Six months		2,210								
	431				2.381	47.5			2.38	47.5
Seven months		1,779								
	260				3.357	55.4			3.36	55.4
Eight months		1,519								
	434				4.733	61.6			4.73	61.6
Nine months		1,084								
	463				6.674	56.9			6.67	56.9
Ten months		621								
	511				9.411	48.1			9.41	48.1
Eleven months		110								
	110				13.269	7.3			13.27	7.3
Twelve months		0								
TOTAL LOSS				191.1		639.9		1,693.3		2,524.3
Percentage of actual production at maturity			1.28		4.27		11.31		16.86	

Table V-2. Loss reduction intervention: Crib drying followed by shelling and insect treatments

	Disposal and/or loss during period	Stored at end of period	Type of loss: Bird loss		Insect loss		Mold loss		Total loss	
	('000 bags)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)
Potential production at maturity	191	15,164	1.26	191.1					1.26	191.1
Actual production at maturity	93	14,973			.622	93.1	5.52	826.5	6.14	919.6
Actual production at harvest time	2,370	14,880			.117	16.0	4.11	562.9	4.23	578.9
One month after harvest	2,606	12,510			.303	34.0	2.07	232.0	2.57	266.0
Two months	1,826	9,904			.602	54.2	.80	71.9	1.40	126.1
Three months	2,159	8,076			.21	18.9			.21	18.9
Four months	2,291	5,917			.29	30.0			.43	30.0
Five months	1,416	3,626			.42	20.0			.42	20.0
Six months	431	2,210			.60	17.5			.60	17.5
Seven months	260	1,779			.84	16.75			.84	16.75
Eight months	434	1,519			1.18	19.13			1.18	19.13
Nine months	463	1,084			1.67	21.73			1.67	21.73
Ten months	511	621			2.35	20.03			2.35	20.03
Eleven months	110	110			3.32	12.13			3.32	12.13
Twelve months		0								
TOTAL LOSS				191.1		273.45		1,693.3		2,257.85
Percentage of actual production at maturity			1.28				2.05		15.05	

Table V-3. Loss reduction intervention: Early harvest and platform drying

	Disposal and/or loss during period	Stored at end of period	Type of loss: Bird loss		Insect loss		Mold loss		Total loss	
	('000 bags)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)
Potential production at maturity	191	15,164	1.26	191.1					1.26	191.10
Actual production at maturity	93	14,973			.622	93.10	1.38	205.99	2.00	299.73
Actual production at harvest time	2,370	14,880			.117	16.02			.12	16.00
One month after harvest	2,606	12,510			.303	33.96			.30	33.96
Two months	1,826	9,904			.602	54.12			.60	54.12
Three months	2,1[illegible]	8,076			.849	59.40			.85	59.40
Four months	2,[illegible]	5,917			1.198	57.16			1.20	57.16
Five months	1,41[illegible]	3,626			1.689	49.29			1.69	49.29
Six months	431	2,210			2.381	47.49			2.38	47.49
Seven months	260	1,779			3.357	55.36			3.36	55.36
Eight months	434	1,519			4.733	61.60			4.73	61.60
Nine months	463	1,084			6.674	56.90			6.67	56.90
Ten months	511	621			9.411	34.40			9.41	34.40
Eleven months	110	110			13.269	7.30			13.27	7.30
Twelve months		0								
TOTAL LOSS				191.1		626.10		206.6		1,023.81
Percentage of actual production at maturity			1.28		4.180		1.38		6.84	

Table V-4. Loss reduction intervention, early harvest, platform drying, and complete insect treatment

	Disposal and/or loss during period	Stored at end of period	Type of loss: Bird loss		Insect loss		Mold loss		Total loss	
	('000 bags)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)
Potential production at maturity		15,164								
	191		1.26	191.1					1.26	191.00
Actual production at maturity		14,973								
	93				.62	93.10	1.38	202.99	2.00	299.09
Actual production at harvest time		14,880								
	2,370				.03	4.10			.03	4.10
One month after harvest		12,510								
	2,602				.08	8.95			.08	8.95
Two months		9,904								
	1,826				.15	13.48			.15	13.48
Three months		8,076								
	2,159				.21	14.70			.21	14.70
Four months		5,917								
	2,291				.30	14.30			.30	14.30
Five months		3,626								
	1,416				.42	20.04			.42	20.04
Six months		2,210								
	431				.60	11.96			.60	11.96
Seven months		1,779								
	260				.84	13.85			.84	13.85
Eight months		1,519								
	434				1.18	15.40			1.18	15.40
Nine months		1,084								
	463				1.67	14.24			1.67	14.24
Ten months		621								
	511				2.35	8.59			2.35	8.59
Eleven months		110								
	110				3.32	1.66			3.32	1.66
Twelve months		0								
TOTAL LOSS				191.1		226.60		206.60		624.30
Percentage of actual production at maturity			1.28		1.53		1.37		4.169	

Table V-5. Loss reduction intervention: Early harvest, platform drying, shell and treat one-half

	Disposal and/or loss during period	Stored at end of period	Type of loss: Bird loss		Insect loss		Mold loss		Total loss	
	('000 bags)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)
Potential production at maturity	191	15,164	1.26	191.1					1.260	191.10
Actual production at maturity	93	14,973			.622	93.10	1.38	205.99	2.020	299.09
Actual production at harvest time	2,370	14,880			.117	16.00			.117	16.00
One month after harvest	2,606	12,510			.303	33.90			.303	33.90
Two months	1,826	9,904			.602	54.10			.602	54.10
Three months	2,159	8,076			.210	14.70			.210	14.70
Four months	2,291	5,917			.300	14.30			.300	14.30
Five months	1,416	3,626			.420	12.25			.420	12.25
Six months	431	2,210			.600	11.96			.600	11.96
Seven months	260	1,779			.840	13.85			.840	13.85
Eight months	434	1,519			1.183	15.35			1.180	15.35
Nine months	463	1,084			1.670	14.24			1.670	14.24
Ten months	511	621			2.350	8.58			2.350	8.58
Eleven months	110	110			3.320	1.82			3.320	1.82
Twelve months		0								
TOTAL LOSS				191.1		304.10		205.99		701.00
Percentage of actual production at maturity			1.28		2.030		1.37		4.680	

Table V-6. Medium harvest, dry in narrow crib, shell, and treat one-half

	Disposal and/or loss during period	Stored at end of period	Type of loss: Bird loss		Insect loss		Mold loss		Total loss	
	('000 bags)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)	(%)	('000 bags)
Potential production at maturity	191	15,164	1.26	191.1					1.26	191.10
Actual production at maturity	93	14,973			.310	46.40	2.75	411.76	3.06	458.16
Actual production at harvest time	2,370	14,880			.117	16.02	2.05	280.70	2.05	296.72
One month after harvest	2,606	12,510			.303	33.96	1.03	115.40	1.03	149.26
Two months	1,826	9,904			.602	54.12	---	---	.60	54.12
Three months	2,159	8,076			.210	14.69	---	---	.21	14.69
Four months	2,291	5,917			.300	14.31			.30	14.31
Five months	1,416	3,626			.420	12.26			.42	12.26
Six months	431	2,210			.600	17.51			.60	17.51
Seven months	260	1,779			.840	13.85			.84	13.85
Eight months	434	1,519			1.200	19.79			1.20	19.79
Nine months	463	1,084			1.700	22.13			1.70	22.13
Ten months	511	621			2.300	19.61			2.30	19.61
Eleven months	110	110			3.300	12.06			3.30	12.06
Twelve months		0								
TOTAL LOSS				191.1		296.70		807.86		1,295.57
Percentage of actual production at maturity			1.28		1.980		5.39		8.65	

A very large number of models could be conceived and evaluated but these seemed to be the most logical. Table V-2, V-3, V-4, V-5 and V-6 show the losses which occur with each of the interventions selected. Table V-7 summarizes the loss results from all models. Table V-7 shows that the most dramatic reductions can be made by harvesting early to reduce field losses followed by platform drying to eliminate the mold losses while corn dries in the crib.

After examining the savings shown in Table V-7 it was concluded that early harvesting, platform drying and insect treatment for one-half the grain is probably the most attractive alternative for further analysis. This will reduce losses by about 72 percent, equivalent to KSh 213,000,000 ($29,600,000). (The assumed price of maize was 1.30 KSh/kg which is the average peak season price for 10 reporting markets for the year 1978.)

Advantages seen for this recommendation include:

(1) Harvest is spread over a one month period which should reduce peak labor requirements.

(2) Harvest will be completed about one month earlier giving more time to prepare for the next crop in two crop regions.

(3) The only new facilities required will be a relatively inexpensive drying platform which can usually be made from local materials, a mat to lay on the platform when drying shelled corn and a cover to protect from rain. The cover can be sheet metal for greater durability, but higher first cost; or a plastic sheet, which would be much cheaper but less durable.

(4) Existing cribs need not be replaced but should eventually be replaced with cribs or storages which provide better rodent protection and better ventilation.

(5) By shelling and treating only half the crop there will be a lower cost for insect protectants and if insect-proof containers (gourds, jars, etc.) are used only half as many will be required. If insect-proof containers are used insect losses should be reduced almost 100 percent of half the crop rather than the 75 percent on which was assumed here.

Evaluation of the cost-benefit ratio for the farmer will be based upon an assumed production of 1,440 kg of maize which is about the average for small farmers interviewed. Operating costs under the revised system were considered as:

(1) Harvesting costs will not depend on time of harvest.

(2) Costs of spreading ear corn on the platform and turning it will be additional costs estimated at 2 hours/day for 28 days.

(3) Shelling costs will not change. Maize must be shelled at some time and the selected system only requires shelling one-half of the crop during a one month period.

Table V-7. Effect of interventions on reduction of maize losses

Type of treatment	Present practice	Crib drying, shell, insect treatment	Early harvest, platform dry	Early harvest, platform dry, treat 100%	Early harvest, platform dry, treat 50%	Medium harvest, dry in narrow crib, treat 50%
Total loss, '000 bags	2,524.0	2,257.0	1,023.0	624.0	701.0	1,295.00
Loss, percent	16.8	15.0	6.9	4.2	4.6	8.65
Reduction in loss, '000 bags		267.0	1,501.0	1,900.0	1,823.0	1,229.00
Reduction in loss, percent		10.0	59.0	75.0	72.0	49.00
Value of grain saved, '000KSh*		31,000.0	175,638.0	222,000.0	213,000.0	149,000.00
Value of grain saved, '000$		4,305.0	24,394.0	30,800.0	29,583.0	20,000.00

* Value of grain at 1.30 KSh/kg

(4) Insect treatment costs include the full cost of chemicals. Ashes, which are frequently used now, have no economic value, and the present level and cost of chemicals is not known. Labor for treating is not included because only one-half the crop is to be treated and presently about one-half the grain is treated.

Table V-8 shows the farm costs and benefits expected under the proposed system. It shows a discounted benefit cost ratio of 4.3 to 1 (4.3:1), excluding labor, and a return to labor of KSh 3.8/hour.

The threshold value at which the cost-benefit ratio becomes 1:1 is a production of approximately 4 bags. The average under 0.5 hectare holding produces 5.5 bags. Hence even the average smallest holding will receive a positive return and all holdings of over 0.5 hectare will receive greater benefits. The very small producer who could not afford a platform alone or with neighbors could still sun dry the very small quantity, and although mat drying in the sun would take a few days longer this small producer could achieve a similar percentage loss reduction.

Very small producers, those who produce in the range of below three bags (270 kg), probably experience low losses presently. This level of production will not feed a normal family for more than a few months. By the time the next crop is mature harvesting at maturity followed by sun drying probably occurs frequently enough to supply immediate family needs.

2. Evaluating Losses of Beans

The loss data for beans shows an average loss of 0.2 percent by insects and about 4 percent by molds, Table IV-18. The loss curve for mold is practically flat indicating that the mold losses originate in the field or during the drying process before threshing. Since the exact time when loss occurs was not determined the following improved system would be recommended:

(1) Pick beans when physiologically mature. Due to the indeterminate maturity of beans this may require two to four pickings--about the same as the normal harvesting for green beans.

(2) Sun dry on the same drying platform used for corn.

(3) Shell and apply insect protectant to those intended for longer term storage.

If the suggested technique would reduce losses by 50 percent this would be applied to the national production.

CBS reported bean production of 1,580,000 bags in 1977 and 1,940,000 bags in 1978. Peak seasonal prices during the period January 1977 to October 1978 for beans was 3.03 KSh/kg as reported by Schmidt et al. (4). The Integrated Rural Survey, 1974/75 reported 144 kg/holding.

Table V-8. Costs and returns associated with recommended innovations on a small farm (five-year period)

	1	2	3	4	5
	---------KSh----------				
First costs and investment items					
Drying platform with mat	155				
Plastic cover	20			20	
Annual cost items (treat one-half)					
Malathion at 12 KSh/kg	5	5	5	5	5
Total	180	5	5	25	5
Revenues[1/]					
176 kg at KSh 1.3/kg	229	229	229	229	229
Net return (undiscounted)	49	224	224	204	224

Undiscounted benefit - cost ratio[2/]	: 1,145/220	= 5.2
Benefit-cost ratio at 15%	: 767.7/180.4	= 4.3
Return to farmers' labor - 24 hours to construct plus 56 hours annual turning time (over 5 years)	: 1,145 KSh/304 hours	= KSh 3.8/hr (undiscounted)

1/ Losses on 1,440 kg stored:

Present practice at 16.8%	=	242 kg
innovation at 4.6%	=	66 kg
Loss reduction	=	176 kg

Value of loss saved: estimated purchase price to farmer at time when the maize would be purchased: KSh 117 per bag, or 1.3 per kilo. 176 kg x KSh 1.3 = KSh 229

2/ Excludes non-wage family labor for platform construction and ear turning.

The national savings of loss would be approximately:
1,760,000 x 2% = 35,200 bags with a farm value of:
35,200 x 90 x 3.03 = 9,600,000 KSh or = $1,300,000.

Adoption of this practice would not be profitable on the average farm unless the drying platform were in place for maize. The added costs would be very small and yield average farm savings of about KSh 84.

3. Evaluation of Sorghum and Millet Losses

Only 18 samples of sorghum were collected during the field survey. The number of samples collected was too small to determine the effect of storage time on level of loss or to estimate preharvest losses. The average mold loss was 6.3 percent and the average insect loss was 40 percent. Bird losses could not be estimated but are generally estimated to be higher than for maize.

Harvesting at maturity, platform drying, threshing and applying an insect treatment is estimated to reduce losses to 10 percent.

No losses were found in eight samples of millet collected.

The Integrated Rural Survey for 1974-75 reported 445,000 holdings producing an average of 493 kg/holding or a total of 219,000 tons.

Reducing sorghum losses from 46 percent as found to 10 percent would reduce losses from 100,000 T to 22,000 T or a saving of 78,000 T.

With average sorghum prices of 2.37 KSh/kg the loss reduction would have a farm value of KSh 185,000,000 or $25,675,000. It is very doubtful that this loss saving is possible because the percentage loss in the 18 samples found seems inordinately high. However, losses might be reducible by 50 percent to KSh 100 million or $7 to $14 million as a more reasonable estimate.

Farms which have a drying platform for maize would have no additional facility costs when drying sorghum. Few farmers could afford a platform for sorghum alone; average production per household growing sorghum is only about 5 bags.

F. Summary and Conclusions

1. Farm Level

Based upon the results of the loss survey, maize losses now exceed 16 percent; of the losses, about 6 percent occur between maturity and harvest and 10 percent between harvest and time of consumption.

The recommendation to reduce these losses:

(1) Begin harvest of the maize at physiological maturity when the moisture is at about 35 percent which will be about four to eight weeks earlier than the present practice.

(2) Sun dry on platform to a safe storage moisture of about 13 to 14 percent.

(3) Shell and apply an insect protectant treatment to about one-half the grain--that to be stored for a period of more than about four months.

This procedure, if followed, is estimated to reduce losses to 4.5 percent.

The farm investment in facilities is estimated to be less than 200 KSh and the five-year cost benefit ratio is estimated at 1:5.2 with a return to additional labor of 3.8 KSh/hour.

The recommended change in technique involves procedures which are well known in Kenya. Most farmers know that grain can be harvested at about maturity and dried in the sun because so many, particularly smaller farmers, practice this to obtain grain for immediate consumption when supplies of the last crop are depleted. Platform drying is well known because the technique is widely used for drying coffee and pyrethrum. The use of insect protectants is well known because 40 percent of the smallholders interviewed now practice it.

Losses of beans and sorghum can be reduced by the same basic techniques.

The Chapter VI details project components which directly impact on small farmers including:

(1) Grants to farmers to install improved facilities.

(2) Formal training programs for farmers.

(3) Training of extension personnel in loss reduction so they may more adequately teach farmers improved techniques during their normal contacts in the field.

2. Off-Farm Level

Chapter VI gives details of inputs needed in a grain loss reduction program at a level above the farm. Major recommendations include:

(1) Institutionalizing grain loss reduction by forming a new branch within the Ministry of Agriculture.

(2) Instituting a broad educational program to improve the technical knowledge of persons working in the field of agriculture. These programs range from provisions for University education at the Master's Degree level down to two week short courses for extension agents.

(3) Widening and strengthening the existing research program to develop and test new techniques of loss reduction.

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3. Mbaja, G. O., and de Graaf, J. The Marketing of Maize and Beans by Cooperatives in Kenya. (KEN/75/005) Draft Field Document, Marketing Development Project, Government of Kenya, UNDP and FAO, Nairobi, 1978.

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VI. PROJECT COMPONENTS

Introduction

The project components presented here are ones which will contribute in a rational and orderly manner to the development of a program for reducing farm and rural grain losses. They reach from the farm level where direct inputs will be made to demonstration farms, through various educational activities from extension personnel at the location level to university graduate programs, and end with institutional development such as the establishment of a Post-Harvest and Storage Section within the Ministry of Agriculture.

Many government agencies are involved. The agencies were selected to include those whose support is needed for a broad development program of this type and who expressed an interest in being involved in the program. The basic factors in each component were developed after consultations with the agencies involved and AID Mission staff.

The overall scope of the program has been adjusted to fall within a budget range prescribed by AID for the project.

Basic components of the project include:

Direct assistance to demonstration farmers for improved storage and drying facilities.

Training and education of farmers through FTC courses, local meetings and short courses, extension agent personal contacts and mass media programs.

Training of trainers including extension and FTC personnel.

Education of professionals at agricultural colleges and the University. A limited amount of education and training of professionals abroad is included.

A limited research component is included. These are very applied projects intended to test basic concepts under Kenyan conditions.

A national grain quality testing laboratory is established to provide a service function for other agencies such as the extension service and the Central Bureau of Statistics. The latter agency plans a program to monitor grain storage losses at the farm level just as it now gathers other agricultural statistics.

A Post-Harvest and Storage Section is established within the Ministry of Agriculture to coordinate the activities of other agencies and to lend support capabilities where required.

Project Component A:
The Establishment of A Post-Harvest and Storage Section (PHSS) Within The Ministry of Agriculture

1. Project Description

Functions necessary to partially support an applied, field directed post-harvest capability are currently located in three MOA departments: The Crop Production and Land Development Divisions and the NAL. Partially absent from or not fully developed in these departments are engineering, agronomy, and biology functions specific to postharvest handling and storage. There is no institutionalized monitoring of postharvest problems. There are few training programs dedicated to postharvest handling and storage techniques.

Thirteen separate MOA department heads have enthusiastically supported the development of a stronger and more clearly organized Ministry capability in postharvest technology. This area is seen as vital to national development. The study team has concluded that a major institutional innovation, the establishment of MOA Post-Harvest Section under the Director of Agriculture, is the best method to channel MOA support and to develop and focus Ministry capability to deal with field-level post-harvest problems. This innovation has been discussed with Ministry department heads concerned, including the Deputy Director of Agriculture, and has been supported. The Study team therefore recommends that USAID assist GOK to establish an MOA Post-Harvest Section, under the Director of Agriculture.

The assistance recommended, and the GOK participation needed to make the assistance effective, includes the following:

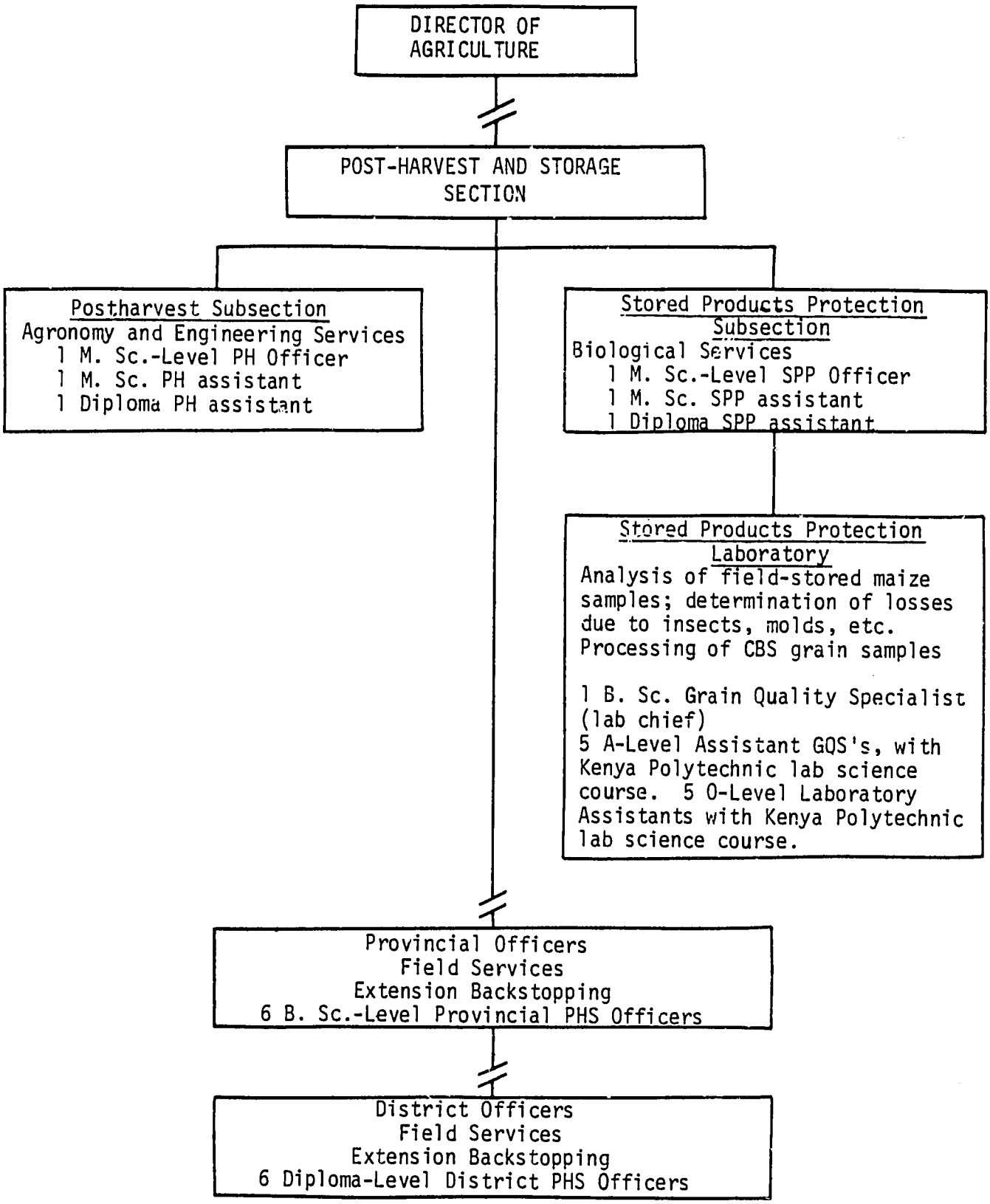
- GOK will establish the Section, detail the services it is to perform, and indicate the number of positions to be created and the responsibilities of each new officer.
- USAID will train Section technical staff, including field staff.
- USAID will fund the construction of and the equipment for a stored products protection laboratory.
- USAID will provide three expatriate technicians for three years each, to assist the initial implementation of the PHSS.

a. Structure of the PHSS

An organogram of the proposed PHS Section is shown on Figure VI-1. As the Figure indicates, the Section has the following structure:

- A Director, located at Nairobi headquarters;
- A Post-Harvest Subsection, including the agronomy and agricultural engineering functions, located at Nairobi headquarters;

Figure VI-1. Organogram for Post-Harvest and Storage Section, MOA (end of project year 5 condition)



- A Stored Products Protection Subsection, including the biological functions, located at Nairobi headquarters;
- A Stored Products Protection Laboratory, to provide the service functions of identification, classification, taxonomy, and evaluation of field grain samples, located at Nairobi headquarters.
- A field staff, to provide extension services, located in provincial and district MOA field offices.

The organogram depicts the status of the proposed Section at the end of the 5 year project period. The year 5 condition shown will be attained through a steady implementation process designed to develop (train) the required special expertise and to create new MOA positions at a rate the Ministry can absorb. The recommended implementation process is outlined in Figure VI-2.

b. Functions and Personnel of the PHSS

The Post-Harvest and Storage Section will, in one organizational entity, provide technical backstopping and services in the areas of post-harvest handling, stored products protection to the MOA's field and extension staff. Field and extension staff will provide headquarters with information on post-harvest and storage problems.

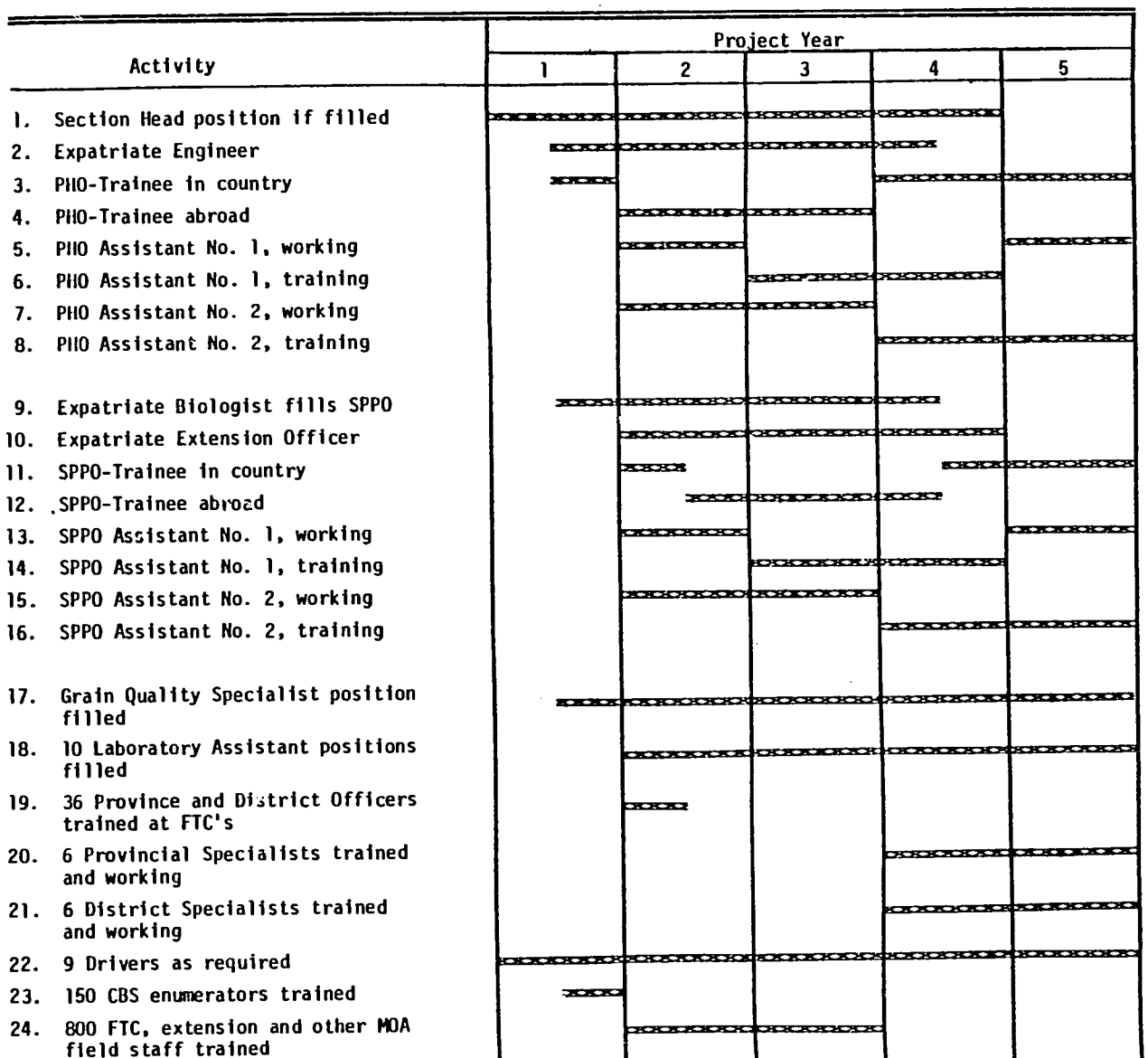
The Post-Harvest Subsection - This section will provide technical support services in the areas of harvesting, threshing, drying, storage, processing and movement. These will be carried to the field staff in appropriate form. Subsection personnel will travel throughout Kenya and lend expertise to the solution of postharvest problems. The Subsection must liase and coordinate activities with other institutions working in the postharvest area: NAL, research stations, training institutions, cooperative unions, and other MOA departments.

The Post-Harvest Subsection will be staffed at headquarters level by a M.Sc. level Post-Harvest Officer (PHO) and two assistants. The assistants should be diploma or degree level. These are engineering and agronomy functions. The officers should have qualifications in agricultural engineering or agronomy, with appropriate course work or experience. A knowledge of farm structures and grain drying will be particularly important for the engineers.

The Stored Products Protection Subsection - This section will provide technical support services in the areas of entomology, microbiology, mycology, and mammology (rodents). In these subject areas, functions are similar to those of the Post-Harvest Subsection:

(1) involvement with and information on applied stored products protection research and technique;
(2) carry these to the field;
(3) travel to problem areas and support the field solution of stored products problems; and
(4) liase and coordinate with other institutions working on stored products protection.

Figure VI-2. Implementation plan for Post-Harvest and Storage Section



(1) Position may be filled on interim basis by expatriate until Kenyan is appointed.

The Stored Products Protection Subsection will be staffed at headquarters level by a M.Sc. level Stored Products Protection Officer (SPPO) and two assistants. The assistants should be diploma or degree level. These are biological functions. The officers should have qualifications in entomology, microbiology, plant pathology, or other biology field, with coursework or experience in the service areas listed. A familiarity with molds, toxins, and insects affecting stored grain will be particularly useful.

Extension activities will be a very important role of the Post-Harvest and Storage Section. Some of the personnel should be selected because of past experience in extension activities. Also, because of the important role of farm women in grain storage including women farm owners and operators, it is strongly recommended that one or two of the assistants be selected from women with an academic background and experience in agriculture and extension.

The Stored Products Protection Laboratory will be headed by a Grain Quality Specialist (GQS). The GQS will have five assistants (Assistant GQS) and five lab technicians. The GQS should be a B.Sc. degree biologist with course work in entomology and mycology; taxonomy and classification will be major aspects of the work. On-the-job training will come from the PHO and SPPO, and with possible additional TPI or USA training. The Assistant GQSs should be A-level graduates, while the lab assistants should be O-level graduates. All assistants should receive a lab technicians course at the Kenya Polytechnic in Nairobi.

A Stored Products Protection Laboratory will be within this Subsection. This will be a service and not a research laboratory. The taxonomy and evaluation of molds, toxins, and insects in stored grain samples will be the major service. A function which may develop over time will be the study of pesticide residues. The laboratory will report to the head of the Stored Products Protection Subsection, so that appropriate field action can be taken.

A second laboratory function, perhaps its most important during its first five years, will be to process the nationwide grain samples collected by Central Bureau of Statistics enumerators. These will be required to generate baseline and five year project evaluation data. Subsection personnel will train CBS enumerators to gather grain samples, to take moisture readings, and to execute any other sampling and handling tasks required by the project.

During the third and fourth year of the project the work load of the Stored Products Protection Laboratory will be relatively light. It is recommended that some of the laboratory technicians be moved to the field to evaluate the performance of new facilities and practices under actual farm operating conditions. This will supply additional and probably more accurate loss data on existing practices as compared to improved practices. The detailed methodology for this study is included in the Appendix Chapter VI.

Extension - Service technical capabilities will be strengthened through the eventual posting of Provincial and District Post-Harvest and Storage Officers (PPHSO's and DPHSO's). It is envisaged that at a future time, well after the present project's conclusion, such officers will be posted in the six Provinces

and 30 Districts which are primarily agricultural. Due to MOA constraints on the rapid creation of new posts, the current five year project envisages the posting of six provincial and six district PHS officers. Fieldwork in the other 24 districts will be undertaken by existing MOA field staff, who will be trained at regional short courses for this purpose. The primary function of the field officers will be the support of extension staff in their daily work with farmers. Recommended and appropriate postharvest techniques and applied research results will reach farmers in this way. The field officers will also refer grain storage problems to headquarters; this includes submission of grain samples to the SPP laboratory.

Extension during the PHS Section's early years will be undertaken by provincial and district officers in other Ministry departments. These existing officers will be specially trained for this purpose.

Field staff will have the normal qualifications for their respective posts: B. Sc. for Provincial level and College diploma for district level. Agricultural engineering, agronomy, entomology, microbiology, plant pathology, biology, and home economics would be appropriate degree or diploma fields. Training should include coursework tailored to postharvest and storage problems.

Summary Chart VI-I indicates the quantity, timing, purpose, and probable source of funding for each item proposed for the PHSS.

c. Implementation Plan

To start this project component, GOK must create the Post-Harvest and Storage Section. Its tasks and its technical and administrative areas of responsibility must be defined. The staff positions must be created, with appropriate job descriptions, and filled. In-country training courses must be scheduled, especially those necessary in the project's first years: the regional FTC in-service training courses for MOA field staff and the CBS enumerator courses. USAID must furnish the three expatriates. A Section head should be appointed as soon as possible.

The Post-Harvest Subsection - After the GOK establishes the PHSS and creates the Post-Harvest Subsection positions, a Kenyan B.Sc. level PHO-trainee should be recruited. An expatriate agricultural engineer with M.Sc. or better should be provided at the same time. The expatriate should overlap with the Kenyan PHO-trainee for six months and he could serve as PHSS head until MOA fills the position with a Kenyan. After six months the Kenyan PHO-trainee should leave for M.Sc. level training in agricultural engineering in the USA. At or shortly before the trainee's departure, the expatriate should be provided with two Kenyan degree or diploma level assistants. At the beginning of project year three one of these assistants should begin M.Sc. training at the University of Nairobi in agricultural engineering or agronomy. About the beginning of project year four, the Kenyan M.Sc. should return from the USA and become the PHO with the expatriate as his advisor for a six month overlap period. At year four, the second assistant should begin his M.Sc. training at the University of Nairobi. During project year four, the Kenyan PHO will have no assistants as the expatriate will have left and both his assistants be pursuing M.Sc. degrees at the University of Nairobi. It is recommended

Summary Chart VI-1. USAID and GOK personnel requirements for the Post-Harvest and Storage Section project component (5 year horizon)

Quantity, item, timing	Purpose	Probable source of funding
KENYAN PERSONNEL		
1. Section Head, B.Sc. or M.Sc. level hired year 1.	Direct Section, administrative responsibility.	GOK (staff positions)
2. 2 Agricultural Scientists for PHSS Headquarters, hired project year 1, for M.Sc. training in USA.	HQ-level technical backstopping and services to support applied MOA programs in post-harvest handling and storage.	GOK (staff positions)
3. Grain Quality Specialist (lab chief), B.Sc. level, hired year 1.	Direct stored products protection laboratory; classify, evaluate pathogens in stored grain samples; train CBS enumerators.	Government of Kenya
4. 4 degree or diploma level assistants, hired project year 2 for M.Sc. training at University of Nairobi.	Assist the PHO and SPPO at HQ.	
5. 10 A or O level SPP lab assistants hired year 2.	Process grain samples arriving from field; process baseline and 5 year samples for evaluation.	Government of Kenya
6. 6 Provincial Post-Harvest and Storage Officers, degree level, 3 hired year 4, 3 hired year 5.	Link field Post-Harvest activities to HQ; technical backstopping of DAO's and DPHSO's	Government of Kenya
7. 6 District Post-Harvest and Storage Officers, diploma level, 3 hired year 4 and 3 hired year 5.	Same as PPHO's	Government of Kenya
8. Nine drivers for project component vehicles.		Government of Kenya
TRAINING		
9. 2 M.Sc. degrees in USA, and 4 M.Sc. degrees in Kenya. Ongoing in years 2 to 5.	To provide HQ with high-level expertise in agricultural engineering, agronomy, microbiology, entomology, or related field.	USAID; GOK for ½ air fares
10. 10 SPP lab assistants, A and O level, estimated at 6 months, year 1 at Kenya Polytechnic.	To do the laboratory processing of field grain samples, under the GQS's supervision.	(hired trained assistants)
11. 12 Provincial and District Officers at 3 months TPI Diploma course, 6 in project year 4, 6 in project year 5.	To provide the PHSS with the first field officers of its own.	USAID; GOK for ½ air fares
12. 150 CBS enumerators for 2 days; 6 courses; field locations. By end of first year. Instruction by National staff.	To teach these CBS personnel how to collect stored grain samples, take moisture readings, kill insects in the samples, and properly forward the samples to PHSS HQ.	USAID for training costs GOK for training costs. This item is costed in the CBS enumerators component.
13. 800 TA's, FTC instructors, other MOA field staff for one week courses (10 courses) at regional FTC's. Instruction by expat PHO and SPPO.	Provide specialized instruction to field staff in the construction of recommended crib designs, grain drying, handling, treatment, and other protection. Teach FTC instructors how to conduct farmer 1 week courses. Present recommended post-harvest techniques to field staff.	Government of Kenya (salaries) USAID for training costs. This item is costed in the farmer training component.
14. 36 Provincial and District Officers to sit in on 2 week FTC field staff training courses.	Provide PHSS field staff (other MOA staffers) with familiarity with the subject matter, until PHSS field officers begin to come in later years.	Government of Kenya
COMMODITIES		
15. Stored Products Protection Laboratory	Process field grain samples: identification, classification, taxonomy, evaluation.	
a. building and physical plant		USAID
b. commodities and equipment (initial)		USAID
c. annual replacement of expendible items; repairs & maintenance.		GOK
16. Nine vehicles plus operating and support items	Transportation for MOA and provincial personnel.	USAID (purchase) GOK (maintenance)
17 Station maintenance		Government of Kenya
OPERATING CAPITAL		
None		
EXPATRIATE TECHNICAL ASSISTANCE		
18. Three M.Sc. or better expats: 1 Agricultural Engineer, 1 Entomologist or Microbiologist arrive year 1 and one extension specialist, arrive year 2, depart year 4 & 5, standard support items.	To fill the PHO and SPPO position. To conduct training courses. To overlap with Kenyan PHO and SPPO Officers.	USAID Government of Kenya to provide support items.

that one or two of the Provincial Post-Harvest and Storage Officers, who are recruited in this year, act as assistants in Nairobi before being posted to one of the provinces. At the end of the project year four, the first assistant now with an M.Sc. will return to the Post-Harvest Subsection. By the end of project year five, with the return of the second assistant, there will be three M.Sc. trained personnel in the Subsection.

Under project component I, M.Sc. students attending the University of Nairobi will be eligible to receive thesis research grants on topics related to postharvest and storage technology. MOA trainees in both the Post-Harvest and Stored Products Protection Subsections should be given favorable consideration when these grants are awarded.

The Stored Products Protection Subsection - After the GOK establishes the PHSS and creates the Stored Products Protection Subsection positions, the implementation procedure parallels that of the Post-Harvest Subsection. A Kenyan B.Sc. level SPPO-trainee is recruited, an expatriate with M.Sc. or better is provided to overlap with the Kenyan on both ends of the USA studies, and two degree or diploma level assistants are provided to the SPPO and receive their M.Sc. training at the University of Nairobi during project years three to five. As with the Post-Harvest Subsection, the Stored Products Subsection will, by the end of the project, have three M.Sc. Kenyans trained in microbiology, entomology, plant protection or extension. One expatriate serving in this branch should be a microbiologist or plant pathologist, and should remain in Kenya for three years, terminating midway through project year four.

Both the Post-Harvest and Stored Products Protection Subsections show potential for strong capabilities in technical areas but not the extension area. Much of the work is aimed at supporting the extension service. Also, women farmers and farm wives have a major role in grain quality maintenance. For these two reasons, it is recommended that at least one of the SPPS assistants be a female drawn from the extension field staff. It is also recommended that an expatriate female be brought into this section for three years to help develop extension activities directed at women farmers. This expatriate extension specialist should have developing country extension experience and a background in agriculture or a relevant biological science. A three-year tour is suggested for the expatriate.

It will be important to staff and equip the stored products protection lab at the very beginning of the project, because the lab will begin processing CBS grain samples as soon as CBS enumerators are trained by the expatriate PHO and SPPO. A qualified Kenyan B.Sc. biological scientist should be hired within the project's first year. The lab assistant positions must also be staffed with Kenya Polytechnic Institute trained assistants at this time.

Extension - Early in year two the MOA should select 36 provincial and district officers from current staff for two postharvest and storage training courses at regional FTC's. A district crops or home economics officer is an example of the type of person who would receive this training. These officers will undertake the PHSS's field functions until the section has its own field staff at a future time. The FTC courses should be conducted by in-country technicians, such as the PHSS expatriates at headquarters, or the Egerton faculty.

During the project's last two years it is proposed that MOA create 6 PPHSO and 6 DPHSO positions, say three of each, each year. The officers recruited would receive three month training courses at TPI in Slough, England. These officers would already be degree of diploma holders. The TPI course would provide intensive and specialized postharvest training.

At a future time as MOA resources permit, DPHSO positions would be created for Kenya's remaining 24 primarily agricultural districts. The officers to be posted could all be trained in Kenya, using expertise developed under this project.

PHS Section Implementation Plan - Figure VI-2 diagrams the recommended PHSS staffing and training plan for the project's first 5 years.

d. Other Implementation Aspects

Section Head - The PHSS head will have primarily administrative duties, although he should be conversant with technical material that is the Section's province.

Force Account Construction of the Stored Products Protection Laboratory - The SPP lab is to provide a vital function beginning at the middle of project year 2, the processing of grain samples collected by CBS enumerators during the 1982/83 integrated rural survey. It is believed that use of normal GOK procurement procedures would delay the lab's completion on time. It is suggested that USAID consider directly financing and contracting for the lab's construction and equipment, and provide this lab to GOK on a turnkey basis.

Training of 150 Central Bureau of Statistics Enumerators - The chief of the Stored Products Protection laboratory (the GQS) will conduct one two-day training course per province (6 provinces) during the first half of 1982, to train the 150 CBS enumerators (see component H), and to provide trained enumerators at the start of the annual integrated rural survey.

Training of 800 Technical Assistants, FTC teachers, or Crops Division Staff - The expatriate PHO and SPPO will conduct 20 one week training courses in Post-Harvest techniques during the project's second and third years. It will be advisable to conduct these courses as early in the project as possible, since these are the officers who will carry the program to the field. They will be conducted at the five regional FTC. Forty TA's and other field staff, FTC teachers, and Crops Division officers will be trained at each course (800 trained altogether).

Training of 10 Stored Products Protection Laboratory Assistants - If the A- and O-level laboratory assistants are not already skilled in laboratory science, they should take a training course at the Kenya Polytechnic Institute. It is believed that this is a one year course, but a candidate with proper background would not require one year's training. These assistants must be on-the-job during the project's second year. They should be already trained when hired, so that the training cost to the project is nil.

2. Requirements and Constraints

a. GOK Participation

The first requirement is the GOK's agreeing to this institutional innovation, with all its implications. The administrative mechanism must be set up in GOK to provide the services discussed. This implies the creation of positions, the hiring of staff and their training, the procurement of goods and services, the acceptance of the expatriates, and the general agreements to incorporate the required administrative mechanisms within ongoing Ministry operations.

b. Critical Year One and Two Activities

It will then be necessary to program and begin the activities critical during the project's first and second years. The activities are very much interrelated and interdependent. The GQS has to be on stream to train the CBS enumerators, the GQ assistants must be in place to process the grain samples forwarded by CBS enumerators, and the lab must be built, equipped, and functioning for these activities to be possible. The expatriate PHO and SPPO must be on board to overlap with the Kenyan PHO and SPPO trainees, and to train the FTC and MOA field staff at farmer training centers, and so on. Figure VI-2 shows the time frame for critical components.

3. Elements and Costs For This Project Component

This section verbally summarizes the material found on Summary Chart VI-1 and on Table VI-1, "Project component estimated costs: Ministry of Agriculture Post-Harvest and Storage Section." Because of the detail in this material, the present summary is brief.

a. Kenyan Personnel

During the project's 5 year life, GOK is expected to provide personnel as follows:

- 1 B.Sc. or M.Sc. person for Section Head;
- 6 B.Sc. degree holders for the PH and SPP officers and their assistants;
- 1 B.Sc. officer to direct the SPP lab (the GQS);
- 5 A-level and 5 O-level officers with Kenya Polytechnic lab science certificates;
- 12 provincial and district level officers (the PPHSO's and DPHSO's).

Cost to GOK is estimated at KSh 153.5 thousand in the project's first year, rising to KSH 1,261.8 thousand during project year five. Total life of project Kenyan personnel costs to GOK are estimated at KSh 3,587.3 thousand.

Costs to USAID for Kenyan personnel are estimated at nil.

Table VI-1. Project component estimated costs: Ministry of Agriculture Post-Harvest and Storage Section (1,000's @ 1980 prices)

	Project Year 1		2		3		4		5		Est. 5 year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
KENYAN PERSONNEL (Salaries)												
1.* 1 Section Head	36.0	---	36.0	---	36.0	---	36.0	---	36.0	---	180.0	---
2. PH & SPP Officers	36.0	---	57.6	---	57.6	---	72.0	---	72.0	---	295.2	---
3. 1 GQS lab Chief	15.0	---	30.0	---	30.0	---	30.0	---	30.0	---	135.0	---
4. 4 PH & SPP Assistants	---	---	120.0	---	108.0	---	96.0	---	108.0	---	432.0	---
5. 5 A and 5 O-level SPP	---	---	140.0	---	140.0	---	140.0	---	140.0	---	560.0	---
6. 6 Provincial & 6 District officers	---	---	---	---	---	---	188.1	---	368.1	---	556.2	---
7. Drivers	12.0	---	24.0	---	24.0	---	36.0	---	60.0	---	156.0	---
8. All Personnel Support for Kenyan Officers	54.5	---	224.2	---	217.6	---	329.1	---	447.7	---	1,273.1	---
Subtotals	153.5	---	631.8	---	613.2	---	927.0	---	1,261.8	---	3,587.3	---
TRAINING PROGRAMS												
9. 6 M.Sc. degrees for Kenyans	---	---	18.7	50.0	---	64.8	---	24.4	---	12.2	18.7	151.4
10. 12 TPI Certificates for PPHSO's & DPHSO's	---	---	---	---	---	---	40.8	28.9	40.8	28.9	81.6	57.8
Subtotals	---	---	18.7	50.0	---	64.8	40.8	53.3	40.8	41.1	100.3	209.2
COMMODITIES												
11. SPP Laboratory	---	157.3	41.1	---	41.1	---	41.1	---	41.1	---	164.4	157.3
12. 9 Vehicles (all costs)	17.1	30.0	46.2	---	58.3	---	75.4	30.0	121.6	30.0	318.6	90.0
13. Station maintenance	100.0	---	100.0	---	100.0	---	100.0	---	100.0	---	500.0	---
Subtotals	117.1	187.3	187.3	---	199.4	---	216.5	30.0	264.2	30.0	983.0	247.3
EXPATRIATE TECHNICAL ASSISTANCE (Salaries)												
14. 3 Expatriates for PHO & SPPO	---	150.0	---	450.0	---	450.0	---	300.0	---	---	4,670.6	1,350.0
GRAND TOTALS	270.6	337.3	837.8	500.0	812.6	514.8	1,184.3	383.3	1,566.8	71.0	4,670.6	1,806.5
Estimated Foreign Exchange Component of GOK costs ($US 1,000):	2.4		12.1		13.8		16.2		22.6		67.1	
Estimated costs in current prices @ 15% inflation per year:	310.6	387.9	1,108.0	661.2	1,235.9	782.9	2,071.3	670.4	3,151.4	287.2	7,377.2	2,789.6
Estimated loan component of USAID costs, current prices:		226.9		52.9		---		---		---		279.8

* Reference notes on following page.

Notes to Table VI-1

KENYAN PERSONNEL: Note: All GOK Officers receive 80 percent of full salary and benefits while in in-service training.

1. Section head position filled by Kenyan as soon as possible.

2. PHO and SPPO trainees hired at full salary for one-half of year one, then paid 80 percent salary while in training. Two-year training period, return beginning year four. Starting salaries: KSh 36,000 (1980/81 level).

3. GQS hired in project month six; starting salary: KSh 30,000 (1980/81).

4. Two degree or diploma assistants for each senior officer. All hired year two. Two leave for M.Sc. training in year three; two more in year four. Starting salaries: KSh 30,000 (1980/81 level).

5. All lab assistants trained and working by beginning of year two. Average salary KSh 14,000 (1980/81 level). Note: Lab assistants should hold KPI lab science certificates when hired.

6. Three provincial (degree) and three district (diploma) officers hired year four; three more of each year five. Starting salaries: provincial, KSh 36,000; district, KSh 30,000 (1980/81 levels). All 12 officers receive 3 month TPI courses during the year they are hired.

7. Grade 3 driver, each KSh 8,000; three hired in 6th project month, three at mid-year four, three at mid-year five (1980/81 levels).

8. Support costs for GOK personnel estimated from data supplied by MOA. These are calculated at 55 percent of personnel salaries, and include housing allowances, uniforms, and travel and accomodation while on duty in country.

9. For PHO and SPPO trainees, two years each in USA at $US 2,500 per month (1980 cost). Air fare each--$US 2,600 return. GOK pays one way fare (KSh 9,360 in 1980); USAID pays one air fare home. For remaining four M.Sc. students, KSh 44,000 per year at University of Nairobi.

10. Six trainees, year four, six trainees, year five. Cost per trainee (1980 basis):

Training fee:	£75/ week x 13 weeks = $US 2,243
Return air fare NBO-LHR:	KSh 13,600 = $US 944 + KSh 6,800 (GOK pays one-half)
Accommodation, food, UK transport, pocket money:	£235/month x 3 = $US 1,622

(Note: KSh 7.2 = $1.00 = £0.435

Hence, costs per trainee = $US 4,809 + KSh 6,800

11. Lab Costs

a. First and annual costs for construction of physical plant. A standard laboratory includes concrete floor, block walls, truss and false ceiling, corrugated roof and plumbing, electricity, and "set" of fixture (workbenches, etc.).

This lab: approximately 10 m x 30 m = 300 m^2; 11 m^2 per technician of work space; 3 small offices; cold room; store w/shelving. COST: KSh 2,800 per m^2, KSh 840,000 = $116,700, incurred year one. Annual R, O, and M at 2.5 percent of 1st COST = $2,920, incurred years two to five. PLUS cold room refrigeration unit: $20,000 year one + $1,000/year O, R, and M years two to five; Cold Room to be held at 1 to 5° C. Add 40 percent for shipping costs.

b. First cost of equipment. $9,000 as per Table VI-2, incurred year one, plus 40 percent for shipping costs.

c. Annual R, O, and M on equipment. $1,000, incurred years two to five, for maintenance and resupply costs, batteries, glassware, repair, and replacing chemicals. Add 40 percent shipping costs.

Costs		Year 1	2	3	4	5
		(1,000)				
(a) First cost physical plant & fixtures	$	116.7	--	--	--	--
First cost refrigeration unit	$	28.0	--	--	--	--
(b) First cost equipment	$	12.6	--	--	--	--
(c) All R, O, and M	KSh	--	41.1	41.1	41.1	41.1

12. Three 2WD sedan vehicles purchased month 6, month 42 and month 56. Used approximately 12,000 mi/yr. USAID will purchase, GOK will operate. Repair costs estimated at approximately 15 percent per year of first cost.

Item		Year 1	2	3	4	5
Purchase	$US(10,000)	30.0	--	--	30.0	30.0
Operate (gas, oil, tires)	KSh	13.0	25.9	25.9	38.9	64.8
Repair and maintenance	KSh (1,000)	4.1	20.3	32.4	36.5	56.8

13. Estimated by GOK at KSh 100,000/year.

14. Three expatriates at $150,000 per year for all costs: Salary, benefits, transport of family, household goods, personal effects and vehicles; education, post, hardship allowance; housing; per diems; etc. GOK to provide office, secretarial assistance, vehicle (purchased by project), and supplies (paper, pencils, phone, etc.). Two expatriates on line from project year 0.5 to 3.5 and extension specialist starting year two.

Table VI-2. Equipment for grain laboratory

	$/unit	Total $
2 microscopes, binocular wide field 20 to 40 x variable	500 each	1,000
2 microscopes, compound monocular	850 each	1,700
3 balance mechanical, 2,000 gram capacity (Similar to OHAUS 1,620)	140 each	420
4 sets Dockage sieves 2½/64" round, 8/64 triangular 12/64" round, 1/12" round, bottom pan	55/set	120
10 test tube racks 7/8" openings, 12 capacity	8 each	80
1 moisture meter (similar to Burrows Mod-400)	245 each	245
1 sample splitter, Riffle type	110 each	110
1 small bundle thresher	1,800 each	1,800
10 hand tallies, 4 digit	10 each	100
2 portable UV lamps (such as ML-4a Black-Ray)	90 each	180
5 hand corn shellers	4 each	20
3 inspection viewers (such as Seedburo 226)	34 each	102
4 UV tubes (replacement for lamps above)	10 each	42
20 forceps, fine point, 4½-5'	3 each	60
10,000 sample bags, poly 8½" x 18"	8/100	800
10,000 ties, bag, twist	5/1,000	54
10 gross grain samples boxes, 2½-3" dia., plastic	33/gross	330
10 gross shell vials, 2 dram, straight side	10/gross	100
10 gross corks, xxx quality, for 2 dram vials	6/gross	60
10 gross shell vials, 4 dram, straight side	14/gross	140
10 gross corks, xxx quality, for 4 dram vials	7/gross	70
Chemicals to control insect & make aflatoxin tests		500
Mini-columns for aflatoxin		1,000
10 dessicating chambers for mini-columns		140
Total cost of laboratory equipment		8,933

b. Training programs

During the project's five year life it is recommended that USAID fund training for Kenyan participants as follows: 6 M.Sc. courses in the fields of Agricultural Engineering, Agronomy, Entomology, Microbiology (mycology), or Plant Pathology (3 in engineering or agronomy, 3 in biological sciences); and 12 TPI certificate courses at Slough in Agricultural Products Storage or Food Storage.

Total cost to GOK is estimated at KSh 100.3 thousand. This sum covers one way air fares only. All other costs are to be paid by USAID. These vary yearly depending on the number of participants in training in any year. Total USAID cost is estimated at $209,200 over the life of the project.

c. Commodities

During the project's 5 year life, GOK and USAID are expected to share costs for commodities as follows: building, physical plant, equipment, and supplies for one stored products protection service laboratory; purchase, operation, and repairs costs for nine vehicles; and maintenance of GOK station. As a general rule, USAID purchases the commodities while GOK operates, repairs, and maintains them.

Cost to GOK is estimated at KSh 117.1 thousand in project year one, to rise to KSh 264.2 thousand in project year five. Total GOK life of project costs for commodities are estimated at KSh 983.0 thousand.

Cost to USAID is estimated to peak at $US 187.3 thousand in project year one. Total USAID life of project costs for commodities are estimated at $247,300.

d. Expatriate Technical Assistance

The cost of three expatriate technicians for three years each is expected to be borne entirely by USAID (Exception: office space, secretarial assistance, telephone, supplies). Total life of project costs for the nine person years of expatriate service is estimated at $1,350,000.

e. Total Life of Project Estimated Costs for the PHSS Component

Life of project costs for the PHSS component are shown in Table VI-1. Total USAID costs for this component are estimated at $1,806.5 thousand in constant 1980 prices or $2,789.6 thousand in current prices. Of the latter, $279.8 would be suitable for a loan which covers the cost of the SPP laboratory. Total GOK costs for this component are estimated at KSh 4,571.8 thousand in constant 1980 prices or KSh 7,721.6 thousand in current prices. Of the former, $67.1 thousand are estimated as foreign exchange costs, which are associated with vehicle operation, repair, and maintenance, and with the replacement of laboratory chemicals and supplies. Table VI-2 lists equipment and supplies.

Project Component B:
The Training of Staff and Farmers in Post-Harvest and Storage Technology at Farmer Training Centers (FTC's) and Field Training Courses

1. Project Description

Present postharvest practices and losses of grain have been described in Chapter IV of this report. Basically, farmers harvest grain after it has dried somewhat in the field, allowing mold and insect infestation to begin before the grain is put in storage. They store their maize in oversize cribs in which air ventilation is restricted. If they treat grain with insecticide, they do a spotty job and fail to get a uniform application. Thus the greatest need in reducing postharvest losses is to educate thousands of smallholder farmers throughout Kenya to improve their postharvest handling and storage of grain by earlier harvesting, faster drying on platforms, storage in improved design cribs, and better insect and rodent control.

The Ministry of Agriculture presently operates 25 FTCs which offer one-week courses to farmers. There is roughly one FTC in each district of agricultural importance. The team visited 15 of these FTCs. Of these, seven had previously offered a one-week course to farmers on postharvest handling and storage, one planned to do so in the immediate future, and one had been forced to cancel such a course at the last moment due to a lack of trained instructors.

At most, one thousand farmers have attended such courses in the last five years. Basically, the staff at FTCs are not adequately equipped or trained to offer such courses on a larger scale. Their training at Egerton, Embu, or Bukura included little on postharvest handling and storage and frequently they have relied on staff from NAL to teach at those courses.

Most principals and staff at FTCs expressed enthusiasm about expanding training in postharvest handling and storage provided that they were given the training and resources to do so. They agreed that there was a tremendous need and that farmers would be responsive to such a program. Under the present project component, USAID will provide the following support to the FTCs to expand their activities in the postharvest and storage area. Summary Chart VI-2 indicates the quantity, timing, purpose and probable source of funding for each item proposed as assistance to the FTCs.

a. Staff Training

The expatriate Post-Harvest, Stored Products Protection and Extension Officers in the Post Harvest and Storage Section of MOA will offer 20 one-week in-service training courses for MOA personnel during each of project years two and three. These will occur at five regional FTCs, designated by MOA, as follows:

Maseno:	Western and Nyanza Provinces
Kericho:	Rift Valley Province
Wambugu:	Central Province
Machakos:	Eastern Province
Taita:	Coast Province

Each of these courses will be attended by approximately 40 participants from among the PCOs, DCOs, TAs and FTC Principals, farm managers and crops production lecturers in each region. It is considered particularly important that the TAs, and FTC principals, farm managers, and crops production lecturers attend these courses because they are the MOA personnel who have the most direct contact with smallholder farmers.

It is important that these in-service training courses occur as early as possible in the project. The content of these courses will include the following topics:

- postharvest and prestorage handling of cereal grains, beans, and pulses.
- maturity determination, harvest practices, field damage loss and assessment
- monitoring the quality of grain in storage.
- moisture and its measurements, air humidity vs. grain moisture.
- stored products insect identification.
- maintaining the quality of grain in storage, including insect and rodent control.
- practical activities such as building a maize crib, building a drying platform, and conducting drying experiments for both threshed and unthreshed grains.

Because of the important role of women farmers in grain quality maintenance, the home economics extension officers should play a leading role in holding rural community meetings. A very large majority of the female extension officers should be among the 800 MOA staff who are trained.

b. Commodities

The project will equip the five regional FTCs in the first year of the project, and nine more in each of the second and third years of the project. Because the six additional FTCs in Western and Nyanza Province will be participating in project component C--the partial grants to smallholders to erect demonstration cribs and drying platforms--these will be equipped in the second year. Based on the importance of smallholder grain production in Nandi, Baringo, and Kirinyaga districts, it is further recommended that Kaimosi, Baringo and Kamweti FTCs be equipped in the second year. Finally, the remaining nine FTCs will be equipped in project year three. In summary, the following FTCs will be equipped in each of the following project years:

project year one:	Maseno, Kericho, Wambugu, Machakos, Taita
project year two:	Bungoma, Kisii, Bukura, Homa Bay, Siaya, Busia, Kaimosi, Baringo, Kamweti
project year three:	Kenyatta, Narok, Kaguru, Kitui, Waruhiu, Embu, Mtwapa, Oljoro Orok, Chebororwa

Demonstration Cribs and Drying Platforms - The project will equip each FTC in the designated project year with four demonstration cribs and two demonstration drying platforms. The designs are in Appendix Chapter VI. Of the four cribs, there will be one 12 bag capacity crib with a galvanized iron roof, a second with thatch roof, and a third with an optional wall material. The fourth crib will be of a design traditional in the area of each respective FTC, so that farmers who attend courses or simply visit FTCs will be able to compare the quality of grain stored in traditional vs. improved structures. Of the two drying platforms, one will have a portable galvainized iron roof and the other a plastic sheet to protect grain from rain.

The demonstration cribs and drying facilities will be used to store and dry grain and the grain in the cribs will be monitored by FTC staff for moisture content and mold and insect damage while the grain is in storage. The purpose of monitoring the grain is to determine the grain storing qualities of the improved design cribs in different parts of the country. Using the cribs, it will also be possible to conduct simple experiments such as evaluating the effectiveness of insecticides by comparing treated vs. untreated grain, one sample in each of two cribs.

The following monitoring procedures are recommended. During the first month in storage, five ½ kg samples of grain should be taken from each crib once a week, during the second and third months, twice a week, and from the fourth month until the next harvest, once a month.

The five samples should be taken from the following places:

- the top in the center
- the bottom in the center
- the center of the windward side wall
- the center of the leeward side wall
- the extreme center of the crib

First, the moisture content of each sample will be taken. The samples will be analyzed for mold and insect damage and screened for the presence of aflatoxin using the procedure outlined in Chapter III of this report. The monitoring of each crib and the assessment of samples will be conducted by FTC personnel at each FTC once the FTC has been equipped with demonstration cribs. Each such FTC will also be equipped with grain quality monitoring equipment, and the personnel will be trained to monitor the grain during the in-service training courses. The results will be recorded and forwarded to the Post-Harvest and Storage Section in the Ministry of Agriculture. FTC personnel will be able to conduct all grain quality analysis prescribed except the aflatoxin assay on samples which glow under the black light. Such samples will be forwarded to the proposed PHSS laboratory where the assay will be conducted.

The improved crib designs recommended in this report are not the final answer to grain storage in Kenya. It is hoped that the monitoring exercise which is carried out at FTCs will lead to a better understanding of the effects of climate in different parts of the country on stored grains and to the design of the even better cribs.

c. Farmer Training

Once the FTC personnel have attended in-service training courses and the FTCs have been equipped with the above commodities, they will be in a position to offer one-week residential training courses in postharvest and storage technology to farmers. Each course will be attended by roughly 50 farmers who pay KSh 15 a week training fee.

It is recommended that each FTC with trained personnel and equipment offer 8 one-week courses a year. It will, however, take some time to reach this level. It is assumed that the 14 FTCs that are equipped in project years one and two will be able to offer an average of four courses in project year two and eight thereafter, while the remaining nine FTCs will offer four courses in project year three and eight thereafter. On this basis, there will be a target of 572 courses offered during the five years of the project attended by approximately 28,600 smallholders, representing approximately 1.5 percent of the smallholders in Kenya.

The following table summarizes the number of one-week farmer training courses that are targeted to take place at the 23 FTCs during the five years of the project.

Table VI-3. Summary of residential training courses held at FTCs

	Project Year					
	1	2	3	4	5	Total
5 FTCs equipped in year one	0	20	40	40	40	140
9 FTCs equipped in year two	0	36	72	72	72	252
9 FTCs equipped in year three	0	0	36	72	72	180
	0	56	148	184	184	572

It will not be sufficient to train farmers only at FTCs. There are target groups, particularly women, who are intimately involved in the postharvest handling and storage of grain and who rarely attend FTCs. Although men in the household typically build the storage cribs, the women are responsible for maintaining the quality of grain in storage, threshing, sorting and grinding at posho mills. To reach target groups who do not normally attend FTCs, MOA already conducts field training courses at community centers, schools, churches, etc. throughout the country. Under IADP, farmers have even become eligible for production credit by attending such field training courses. Following these precedents, it is recommended that TAs, supplemented by FTC and extension personnel, offer field training courses in postharvest handling and storage. It is assumed that in each year one-half as many field training courses as residential courses will be offered, for a total of 286 courses, although more would be desirable. Emphasis should be placed on reaching women farmers.

2. Requirements and Constraints

This component of the project will be administered by MOA. The Ministry will administer the funds provided by USAID to train Ministry personnel and farmers, and to equip FTCs with demonstration cribs and drying platforms, grain quality monitoring equipment, and teaching aids. The Ministry will also be responsible for the operating repair, and maintenance costs of equipment.

The Ministry must release staff in project years two and three for one-week in-service training courses. The Ministry must further reorientate its extension effort, both at FTCs and in the field, towards the postharvest handling and storage of food grains. It must make available 572 weeks of FTC time over the last four years of the project and plan to hold an additional 286 (or more) field training courses at community centers, schools, churches, etc. This will involve a considerable reallocation of MOA personnel time, particularly that of FTC personnel and TAs.

3. Elements and Costs

This section summarizes the material found on Summary Chart VI-2 and on Table VI-4, covering project elements and costs for the training of MOA staff and farmers in postharvest and storage technology.

a. Kenyan personnel

This is not included as a project cost because no new positions will be created within the Ministry of Agriculture or any other government agency under this component of the project. However, this does represent a GOK contribution to the project in the form of salaries of MOA personnel while attending in-service training courses and while training farmers in postharvest and storage technology at FTCs and in the field.

b. Staff Training

The cost of MOA in-service training during project years two and three is expected to be borne exclusively by USAID. Cost to USAID is $30.5 thousand in each year for a total life of project cost of $61.0 thousand.

c. Commodities

During the five years of the project, GOK and USAID are expected to share costs for commodities to equip FTCs with demonstration cribs and drying facilities, grain quality monitoring equipment, and teaching aids. Generally, USAID will pay the initial cost of purchasing the commodities while GOK will pay for operating, repairing, and maintaining them.

Cost to GOK is estimated at KSh 9.0 thousand in project year two rising to KSh 41.4 thousand in project year five. Total GOK costs for commodities over the life of the project are estimated at KSh 117.0 thousand.

Cost to USAID is estimated at $19.4 thousand in project year one and $34.8 thousand in each of the project years two and three. Total USAID costs for commodities over the life of the project are estimated at $US 89.0 thousand.

Summary Chart VI-2. USAID and GOK requirements to train farmers in postharvest and storage technology

Quantity, item, timing	Purpose	Probable source of funding
KENYAN PERSONNEL		
1. Salaries of MOA personnel including PCOs, DCOs, TAs, and principals, farm managers, and crops production lectures at FTCs.	To extend postharvest technology to farmers at FTC courses and in the field.	No additional financial costs since no new positions will be created under this component of the project.
STAFF TRAINING		
2. 20 1-week in-service training courses for above MOA personnel, 10 during each of the first two years of the project. Each course attended by approximately 40 participants.	Located at five designated FTCs, one in each region of the country. To train MOA personnel in postharvest and storage technology so that they can then train farmers.	
a. Accomodation and travel for participants to FTCs.		USAID
b. Instructional materials.		USAID
COMMODITIES		
3. Four demonstration cribs, two demonstration drying platforms at 5 designated regional FTCs in project year one, 9 in project year two (including 6 in Western and Nyanza Provinces), and 9 in project year three.	To be used as stores and instructional models at FTCs.	USAID for materials. GOK for labor in construction.
4. Basic grain quality monitoring equipment for 5 regional FTCs in project year one, 9 in project year two, and 9 in project year three (Table VI-4).	To be used in teaching the concepts of grain quality. To be used to monitor the condition and quality of the grain in demonstration dryers and stores.	USAID
5. Teaching aids for 5 regional FTCs in project year one, 9 in project year two and 9 in project year three (Table VI-4).	To facilitate the transfer of ideas and concepts from teacher to learner.	USAID
6. Operating, repair, and maintenance costs of commodities in 3, 4 and 5 above.		GOK
FARMER TRAINING		
7. Target of 572 one week residential training courses for farmers, 56 in project year two, 148 in project year three, and 184 in project years four and five. Accomodation and travel for approximately 50 participants per course.	Located at 14 FTCs in the second year of the project and 23 FTCs in last three years. These FTCs are located in major grain-producing areas of the country. Training conducted by FTC personnel.	USAID for KSh 20 of KSh 30 total cost per participant per day, GOK for 7.50 and farmers for 2.5.
8. Target of 286 field training courses for farmers, 28 in project year two, 74 in project year three, and 92 in project years four and five.	Located at community centers, schools, churches, etc., throughout the grain-producing areas of the country. Aimed at groups, particularly women who are unable to attend FTC courses. Training done by TAs and/or FTC personnel.	USAID GOK Farmers

Table VI-4. Project component costs: The training of farmers in postharvest and storage technology (1980 prices)

	Project Year 1		2		3		4		5		Est. 5 year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
KENYAN PERSONNEL												
1.* Nil	---	---	---	---	---	---	---	---	---	---	---	---
STAFF TRAINING												
2. Accomodation/travel	---	---	---	25.5	---	25.5	---	---	---	---	---	51.0
3. Instructional materials	---	---	---	5.0	---	5.0	---	---	---	---	---	10.0
Subtotals	---	---	---	30.5	---	30.5	---	---	---	---	---	61.0
COMMODITIES												
4. Cribs/drying platforms	---	3.2	---	5.7	---	5.7	---	---	---	---	---	14.6
5. Grain quality equipment	---	10.9	---	19.6	---	19.6	---	---	---	---	---	50.1
6. Teaching aids	---	5.3	---	9.5	---	9.3	---	---	---	---	---	24.3
7. Operating/repair/maintenance	---	---	9.0	---	25.2	---	41.4	---	41.4	---	117.0	
Subtotals	---	19.4	9.0	34.8	25.2	34.8	41.4	---	41.4	---	117.0	89.0
FARMER TRAINING												
8. FTC training	---	---	105.1	35.9	277.5	102.8	345.6	128.0	345.6	128.0	1,073.8	397.7
9. Field training	---	---	26.5	9.8	70.2	26.0	87.0	32.3	87.0	32.3	270.7	100.4
Subtotals	---	---	131.6	48.7	347.7	128.8	432.6	160.3	432.6	160.3	1,344.5	498.1
GRAND TOTALS	---	19.4	140.6	114.0	372.9	194.1	474.0	160.3	474.0	160.3	1,461.5	648.1
Estimated Foreign Exchange component of GOK costs in $US 1,000	---		1.3		3.5		5.8		5.8		16.4	
Estimated costs in current prices @ 15% inflation per year	---	22.3	185.9	150.8	567.1	295.2	829.0	280.4	953.4	322.4	2,535.5	1,071.1

* Reference notes on following page.

Notes to Table VI-4

KENYAN PERSONNEL

1. GOK contribution includes salaries of MOA personnel while attending in-service training courses and while training farmers in postharvest and storage technology. This is not included as a project cost because no new positions will be created under this component.

STAFF TRAINING

2. Twenty courses in each of project years two and three. Each course includes travel and accomodation for 6 days. Cost assumes that there will be in attendance 1 PCO at KSh 120 per day, 5 FTC principals at KSh 120 per day, 5 DCOs at KSh 90 per day, and 29 TAs, farm managers, and crops production lecturers at KSh 65 per day. MOA staff will generally be housed at the FTC.

3. Cost assumes $12.50 per participant per course; 40 participants at each of 20 courses in years two and three.

COMMODITIES

4. Five FTCs equipped in year one and 9 in each of years two and three. Cost of KSh 4,600 per FTC for one set of four cribs and two drying platforms, KSh 931 per crib and 435.28 per drying platform. See Section 4 below for description of cribs and drying platforms.

5. Five FTCs equipped in year one and 9 in each of years two and three. Cost of $1,552.70 per FTC. See items in Table VI-5. Add 40 percent for shipping costs.

6. Five FTCs equipped in year one and 9 in each of years two and three. Cost of $760.00 per FTC. See Table VI-5. Add 40 percent for shipping costs.

7. For batteries and lamps, $50 per FTC per year after acquisition of equipment. For transparencies, pens, and office supplies $200 per FTC per year after acquisition of equipment.

FARMER TRAINING

8. Fifty-six courses in year two, 148 in year three, and 184 in each of years four and five. All inclusive cost of 27.50 per participant per day, of which USAID pays KSh 20 and GOK 7.50.

9. Twenty-eight courses in year two, 74 in year three, and 92 in each of years four and five. Total cost of KSh 3,470 for one three-day course. This includes travel and accomodation for one FTC principal (KSh 240 per day), 2 TAs (KSh 130 each per day), and one driver (KSh 80 per day); instructional materials of 7.20 for each of 50 participants; and KSh 1,370 for one demonstration crib and drying platform. As for FTC courses above, it is assumed that USAID pays 72.7 percent of costs and GOK 27.3 percent.

Table VI-5. List of estimated commodity requirements for each FTC and cost

	Item description (size/capacity)	Total required	Estimated unit cost	Estimated total cost
			----------$US----------	
	MOISTURE METER			
1.	Portable capacitance type, 220 VAC/Battery	2	250.00	500.00
				500.00
	GRAIN QUALITY TESTING EQUIPMENT			
2.	Dockage sieves for wheat, corn, rice and sorghum with bottom pans	2 sets	55.70	111.40
3.	Grain probe for ear maize	2	57.75	115.50
4.	Bag triers, nickle plated, 1" outside diameter at large end	4	16.00	64.00
5.	UV light (Black light) Battery operated with replacement tube	1	99.20	99.20
6.	Magnifying glass with base	6	24.95	99.80
				489.90
	MISCELLANEOUS EQUIPMENT			
7.	Balance scales, dial type, 2610 gm capacity, 0.1 gm sensitivity	2	131.00	262.00
8.	Hand corn sheller	6	4.33	26.00
9.	Mechanical sheller, hand cranked*	1	52.00	52.00
10.	Hand grinder, cast iron*	1	52.80	52.80
11.	Hand sprayers, 3 gal. capacity*	2	35.00	70.00
12.	Hand duster with blower*	2	50.00	100.00
				562.80
	TEACHING AIDS			
13.	Overhead projector, with two lamps*	1	530.00	530.00
14.	Technical books and manuals		200.00	200.00
	Transparencies for projector*		20.00	20.00
	Office supplies, pens, etc.*		10.00	10.00
				760.00

* Available locally.

d. Farmer Training

During the five years of the project, GOK and USAID are expected to share the costs of farmer training. Generally, about 27 percent of these costs are borne by GOK and 73 percent by USAID. Cost to GOK is estimated at KSh 131.6 thousand in project year two, rising to KSh 432.6 thousand in year five, for a total of KSh 1,344.5 thousand over the five years. Cost to USAID is estimated at $48.7 thousand in project year two, rising to $160.3 thousand in year five, for a total life of project cost of $498.1 thousand.

4. Description of Demonstration Units for FTCs

a. Maize Cribs

There will be at least four demonstration crib designs at Farmers Training Centers participating in this program. One basic crib design will be built in each of the FTCs, with slight modification in regards to locally available materials. The basic design is shown in Appendix Chapter VI drawings. Where applicable, the outer wall material may consist of split sisal poles or split bamboo whichever is readily available in the area. Similarly, the floor may also consist of either round sisal poles, wood poles, or even bamboo poles. However, all structurally supporting parts of the crib should be made of durable wood poles to ensure strong and stable structure. The basic design crib will have a corrugated galvanized roof which will have a gutter to be used in collecting rain water. A rodent-proof device will be provided for each crib by wrapping each post with a sufficiently large sheet of metal just below the floor support. This rodent guard design is relatively easier for a farmer to make as compared to a conically-shaped design which, by normal causes, is easily bent and dilapidated rendering it ineffective. The double-wall concept of the crib design is intended primarily to help conceal the contents of the crib from the peering eyes of the neighbor. The outer wall will also help reduce the amount of rain water entering the crib.

A second crib will be built with all the features of the former except for the roof which will be made of thatch material. The purpose of this variation is to find out, if any, the effect in the normal air-drying process on the quality of ear maize stored or kept in the cribs for further drying. The radiated heat from the metal roof may enhance the drying process of top layers of ear maize in the crib.

A third crib will be built whose design will be identical to the popular crib being used by the small farm holders in the area. For example, in some locations in Embu and Murang'a, farmers have ciruclar cribs made of woven sticks, elevated floor and thatch roof. By building the traditional alongside the improved crib design, a farmer coming to the FTC will have the opportunity to observe the different features of an improved crib design which are practical to his point of view.

An optional storage facility, which will be built, is a simple shed-type structure where various airtight storage containers will be housed. Such containers are locally available tin cans, gourds, earthen pots, jars, and drums. These containers will be used to store small grains, beans and

shelled maize to test the effectiveness of various methods of protecting the grains from insects. These methods include the use of ashes, diatomaceous earth, and chemicals, and sealing the containers to make them airtight whereby insects inside will be killed by lack of oxygen.

b. Drying Platforms

Two drying platforms will be built; the designs are in Appendix Chapter VI. One will have a portable roof of galvanized iron while the second platform will have for its roof a clear plastic sheet. The drying performances of the platforms will be compared. One comparison that can be done is to dry maize in one platform without any cover and in another platform with a plastic sheet cover on. Another test could be made by drying maize on both platforms with their respective covers on. The result of such tests would help identify the best drying technique to be used by farmers.

Project Component C: Partial Grants to Smallholders to Construct Demonstration Cribs and Drying Platforms

1. Project Description

Project component B has addressed the requirements of GOK to train farmers in postharvest and storage technology at residential and field training courses. However, if project component B is fully implemented, only 2.2 percent of smallholders will attend training courses in postharvest and storage technology. In order to have a significant impact on the problem of storage, it will be necessary to reach more smallholders.

The method that is here recommended is to extend partial grants to approximately ten thousand smallholders to construct improved design demonstration cribs and drying platforms. The approach is taken from the hybrid maize program during which the Ministry of Agriculture extension service was successful in organizing thousands of demonstrations to disseminate the new hybrid maize technology. Now, more than one-third of the smallholders in Kenya have found it profitable to grow hybrid maize.

There is already an existing method within the MOA extension service of selecting farmers for the siting of demonstrations of various kinds. Generally, these farmers are known to be more honest, more zealous, more willing to accept expert advice, more willing to show the demonstrations to other farmers, and closer to centers of community activity such as markets.

Another method which might be used to select demonstration sites is to work through formal and informal groups. These might be women's work groups, community development groups or church missions. One or more members would receive the grant but hopefully the entire group would attend training sessions on use of the improved facilities and technology.

Rural level vocational centers, "Village Polytechnic Institutes" might use large numbers of demonstration units effectively.

If elementary schools were to be used on weekends for women farmer training some demonstration units could effectively be placed at or near the schools. Extension experience in the Philippines has shown that women can be reached more easily on weekends.

Farmers who erect demonstration cribs and drying platforms, and agree to demonstrate their use to other farmers, in some cases aided by MOA extension staff, will be assisted in their efforts in the form of a grant that will cover part of the cost of building the crib and drying platform. Specifically, the grant will cover the cost of the galvanized iron roofs of the crib and drying platform, the eight vertical supports of the crib with bolted wood blocks and treated with creosote, the ratguards and the gutter, and nails. The design of the crib and drying platform is the same as those that will be erected at FTCs. The participant farmer will purchase or gather the remaining materials from the field, and will construct the crib himself.

2. Implementation Plan

Summary Chart VI-3 gives an outline of this project component. Because it is experimental in nature, it will be limited to one region of the country--Western and Nyanza Provinces. If the initial experiment is judged a success, GOK may wish to extend to other regions. Western and Nyanza Provinces have been selected because of their importance in the production of grain and because of the way in which participant farmers will receive their construction materials under the project, namely through the ten cooperative unions with which USAID has been working under the SPSCP program.1/

Under the IADP and SPSCP programs, the cooperative unions/societies are the accepted government means of chanelling production inputs to smallholders. MOA and MOCD personnel, along with the cooperative unions and societies, jointly select participants in the program. MOA personnel work out a farm plan in each district and train participants at FTCs to follow these plans. The cooperative unions order the production inputs in these plans from the KFA or another stockist and at the same time apply for a loan from the Cooperative Bank to cover the cost of the inputs. Upon approval of the applications, the Cooperative Bank pays the KFA who deliver the inputs to the union store. Then the unions and societies deliver the inputs to the farmers who utilize them under the supervision of MOA extension staff.

The present program to extend partial grants to smallholders will modify this system somewhat. The participants will be trained by MOA personnel either in residential training courses at FTCs or at field training courses in community centers, schools, churches, etc. Upon completion of the course they will be eligible for the grant. They must further agree to construct both a demonstration crib and a drying platform within a specified time of receiving the materials, and to demonstrate the usage of the crib and drying platform to other farmers. The ten cooperative unions will order the materials from KFA and they will apply for the grant on behalf of the participants, but

1/ Kakamega, Bungoma, Malaba/Malakisi, Nambale, Luanda, Kismu, Victoria, South Nyanza Dairy, Siaya, and Rachuonyo Cooperative Unions.

Summary Chart VI-3. USAID and GOK requirements to extend partial grants to farmers to construct demonstration cribs and drying platforms

(This program is limited to Western and Nyanza Provinces)

Quantity, item, timing	Purpose	Probable source of funding
KENYAN PERSONNEL		
1. Salaries of teaching staff at FTCs	To teach one-week courses at FTCs on postharvest and storage technology.	No additional costs. Already incorporated into FTC component of project.
2. Salaries of TAs	To recruit farmers for residential training courses at FTCs and field training courses at community centers, schools, churches, etc. To teach farmers. To supervise construction of demonstration cribs and drying platforms on smallholdings.	No additional costs. Already incorporated into FTC component of project.
3. Salaries of MOCD and cooperative union/society personnel involved in program.	To process grant application of farmers at all levels. To order supplies and arrange for delivery to farmers.	Government of Kenya Cooperative unions/societies
FARMER TRAINING		
4. Target of 196 one-week residential training courses for farmers, 28 in project year two, and 56 in each of project years three, four and five. Accomodation and travel for approximately 50 participants per course.	Located at 7 FTCs in Western and Nyanza Provinces. Training by FTC personnel. Attendance at course makes farmer eligible to receive a partial grant for the construction of a crib and a drying platform on his smallholding.	No additional costs. Already incorporated into FTC component of project.
TRAINING		
5. Target of 98 field training courses for farmers, 14 in project year two, and 28 in project years three, four, and five.	Located at community centers, schools, churches, etc. in Western and Nyanza Provinces. Aimed at groups, particularly women, who are unable to attend FTC courses. Training done by TAs and/or FTC personnel. Attendance also makes farmer eligible for a partial grant for the construction of a crib and a drying platform on his smallholding.	No additional costs. Already incorporated into FTC component of project.
COMMODITIES		
6. Partial grants to a target of 9800 smallholders (assuming 2/3 of participants at residential and field training courses decide to accept grant) to build crib and drying platform on their smallholding. Grant includes: a. roofs of cribs and drying platform b. eight vertical supports with bolted wood blocks and treated with creosote c. ratguards and gutter d. nails	To induce farmers to construct improved design cribs and drying platforms. Farmers accepting grants must agree to build both a crib and a drying platform, and to demonstrate their usage to other farmers.	USAID SPSCP reflow funds. Participant farmer will purchase or gather remaining materials from the field and build the crib.

they will apply not to the Cooperative Bank but instead to the Ministry of Cooperative Development, MOCD, in turn, will pay KFA who will deliver the materials to the union stores. The unions and societies will deliver the materials to the participant farmers, and MOA extension staff will check that the participants indeed use the materials in the construction of a crib and drying platform as taught at the MOA training course.

It is possible that USAID will obtain funds to extend grants to smallholders from the SPSCP reflow funds which are administered by the Cereals and Sugar Finance Corporation. In this case, MOCD will be reimbursed the money it paid KFA by the Cereals and Sugar Finance Corporation from the reflow funds.

Participant farmers in the program will be trained at the residential and field training courses in Western and Nyanza Provinces already proposed in Chapter VI, Section B.

3. Requirements and Constraints

This component of the project will be administered by MOA and MOCD, who will have the following obligations under the project. Both Ministries will assist the cooperative unions/societies in recruiting cooperative members or groups to participate in the program. Both will work together to schedule the timing of elements in the program including recruiting participants, holding training courses, ordering construction materials, and delivery of materials to participants.

The Ministry of Agriculture will hold the planned number of training courses at FTCs and in the field. Therefore, this project component is contingent upon Project Component B.

All the additional funds provided by USAID under this project component will be administered by MOCD. The Ministry will utilize an existing organization or set up a new organization to do this. It will obtain the agreement of the ten cooperative unions to participate in the program and it will reallocate the time, as necessary, of existing MOCD personnel to work on aspects of this program. Because of the similarities of this program to IADP and SPSCP, it is not anticipated that this will entail any drastic measures in this regard.

4. Elements and Costs

This section summarizes the materials in Summary Chart VI-3 and Table VI-6.

Salaries for Kenyan personnel are not included as a project cost because no new positions will be created within the govenrment of Kenya or cooperative unions/societies under this component of the project. However, this does represent a GOK contribution in the form of personnel involved in the extending of partial grants to smallholders.

Farmers participating in the program will be trained at FTCs and in the field in Western and Nyanza Provinces. These costs, borne by GOK and USAID, have already been incorporated into project component B on farmer training.

Table VI-6. Project component estimated costs: Grants to smallholders to build cribs and drying platforms (1980 prices)

	Project Year 1		2		3		4		5		Estimated 5 year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
KENYAN PERSONNEL												
1. Nil	---	---	---	---	---	---	---	---	---	---	---	---
FARMER TRAINING												
2. Nil	---	---	---	---	---	---	---	---	---	---	---	---
COMMODITIES												
3. Partial grants for cribs/ drying platforms	---	---	---	120.6	---	241.1	---	241.1	---	241.1	---	843.9
GRAND TOTALS	---	---	---	120.6	---	241.1	---	241.1	---	241.1	---	843.9
Estimated costs in current prices at 15% inflation per year	---	---	---	159.5	---	366.7	---	421.7	---	484.9	---	1,432.8

Reference Notes

1. GOK contribution includes salaries of MOA personnel while training farmers in postharvest and storage technology. It also includes the salaries of MOCD and cooperative union/society personnel while processing grant applications of farmers at all levels, ordering supplies, and arranging for delivery to farmers. These are not included as a project cost because no new positions will be created under this component.

2. The cost of farmer training in Western and Nyanza Provinces has already been incorporated into project component B.

3. It is assumed that grants will be given to 1,400 farmers in project year two and 2,800 farmers in each of project years three, four, and five. The cost of the grant components for one crib and drying platform is KSh 620 ($US 86.11)

The only new cost under the present project component involves the cost of the grants to smallholders to build cribs and drying platforms. This will be borne entirely by USAID. Cost to USAID is estimated at $US 120.6 thousand in project year two and $US241.1 thousand in each of years three, four, and five. Total USAID costs over the life of the project are estimated at $US 843.9 thousand in constant 1980 prices or $1,432.8 thousand in current prices.

5. Evaluation of Project Component

This component is experimental in nature. The consultants feel that of the two interventions--the crib and the drying platform--investment in the drying platform alone coupled with early harvesting may represent the most cost-efficient means of reducing on-farm grain losses from the smallholder's point of view. The platform not only costs less but it prevents mold damage by facilitating the drying of grain more rapidly. Therefore, the consultants recommend that by the end of project year two, a special evaluation of this component should be conducted with a view to increasing the number of grants for drying platforms and reducing those for cribs within the existing budget for this component. This evaluation should take into account the experience gained in erecting and using the cribs and drying platforms at FTCs, the first round of MOA in-service training sources, and any other observations made by project personnel. The evaluation should also consider other means of training a larger number of farmers and delivering materials granted to them.

One possible type of grant might be to provide nails, plastic sheets and insecticide to any smallholder who evidences his intentions by constructing a drying platform.

Project Component D: Assistance to Cooperative Unions to Improve Their Grain Marketing Capability

(Introductory Note: This project component is highly desirable from the viewpoint of GOK. Among GOK personnel there is an awareness of the problems addressed, and a willingness to innovate in order to solve them. In particular, MOCD, MOA, the Cooperative Bank of Kenya, and the cooperative unions themselves would like USAID to provide assistance to improve the unions' capabilities of marketing grain. But the design of such a project is extremely complex. It is relatively easy to design a package of technical assistance and commodity grants to MOCD and participating cooperative unions and to cost the elements of such a program, which are covered in sections 1 and 4 below. It is less easy to envisage how cooperative unions can profitably market grain in the long run - which must be a project objective - under present GOK marketing policies and regulations. These are issues discussed in sections 2 and 3 below.

In the light of these difficulties, the Kenya National Crop Storage Team makes the following recommendations:

(1) that USAID should go forward with plans to implement a project of this nature, but that this project should be separate from the grain storage project. The emphases of the two projects are different: the one, to reduce postharvest grain losses on smallholdings, and the other to market and store grain once it has left the smallholding.

(2) that USAID should employ a new design team to design this project. This should consist of one grain marketing expert and one credit expert, each for three months, and each with experience in Kenya. The personnel required could quite likely be found within Kenya.

What follows is the description of a project designed to assist cooperative unions that could be implemented once the new design team has determined the ways in which the cooperative unions can operate in the existing marketing climate and/or the policy changes necessary to ensure their profitable operation).

1. Project Description

Numerous reports and documents have described weaknesses in the present marketing system for maize and beans (1),(2),(3),(4),(5). At present cooperative unions and societies handle about 8 percent of marketed smallholder production of maize and represent an alternative to marketing through market traders, lorry traders, or the National Cereals and Produce Board, or direct sales to the consumer (2). An expanded role for cooperatives has the potential to provide more competition, increase efficiency, and benefit the smallholders who are their members.

It is proposed that cooperative unions and societies would be assisted in a number of ways to increase their role in the marketing of grain. Under the SPSCP program, USAID has already been working with 12 cooperative unions - roughly since 1975/76 - five in each of Western and Nyanza Provinces and two in Eastern Province. In the past two years, these unions have constructed with AID support 44 cooperative stores of either 200 ton or 600 ton capacity. The ten cooperative unions in Western and Nyanza Provinces who have built 37 stores would become the focal point of additional USAID support. Summary Chart VI-4 indicates the quantity, timing, purpose and probable source of funding for each item.

a. Personnel

The project would pay the salaries of 10 grains operations managers (one at each of 10 unions) for three years, beginning with project year two. The grains operations manager would work under the union manager and would be responsible for the overall marketing of maize, beans, and other grains by the union. This would include maintaining uniform bookkeeping practices, scheduling of transport, overseeing the movement of grain between buying centers, cooperative stores, and the National Cereals and Produce Board depots. This individual would be a full-time employee of the union. His

Summary Chart VI-4. USAID and GOK requirements to improve unions' capabilities to market grain

Quantity, item, timing	Purpose	Probable source of funding
KENYAN PERSONNEL		
1. Ten grains operations managers - salaries for three years each.	To be responsible for the overall marketing of grain by each cooperative union. To maintain uniform book-keeping practices, to schedule transport, and to oversee the movement of grain between buying centers, cooperative stores, and NCPB depots.	USAID SPSCP reflow funds.
2. Thirty-seven store clerks - salaries for three years each.	To be responsible for receiving and handling grain at cooperative stores, grading and assembling, and applying insecticides to maintain quality in storage.	USAID SPSCP reflow funds.
3. Counterparts for expatriates	To render technical services to cooperative unions.	GOK
4. Two drivers		GOK
TRAINING		
5. Two 3-week training courses for 10 grains operations managers, one in each of project years two and three. a. Travel and accommodation for participants. b. Instructional materials.	To train grains operations managers in aspects of grain marketing.	USAID SPSCP reflow funds.
6. Three 2-week training courses for 21 store clerks, one in each of project years two, three, and four. a. Travel and accommodation for participants. b. Instructional materials.	To train store clerks in aspects of handling, grading and assembling grain. To train store clerks in the use of equipment for these purposes.	USAID SPSCP reflow funds.
COMMODITIES		
7. Grain-handling equipment, 21 sets supplied in the second year of the project, and 16 in the third year. a. Two moisture meters b. Scales and balances c. Grain quality testing equipment d. Grain cleaning equipment e. One pallet truck	To be located at cooperative stores to assist store clerks in their duties.	USAID SPSCP reflow funds.
8. Maintenance and replacement of above equipment.		Cooperative unions from marketing margins.
9. Construction of grain-drying facilities, 21 in the first year of the project and 16 in the second year.	To be located at cooperative stores. To dry high moisture grain so that it will store well and be accepted by NCPB.	USAID SPSCP reflow funds.
10. Maintenance and operation of drying facilities.		Cooperative unions from marketing margins.
11. Construction of offices and cabinets in cooperative stores, 21 in first year of the project and 16 in the second year.	To assist store clerks in their duties.	USAID SPSCP reflow funds.
12. Maintenance of cooperative stores.		Cooperative union from marketing and storage margins.
13. Insecticides for grain stored in cooperative stores.	To preserve the quality of stored grain.	Cooperation unions from marketing and storage margins.
14. Two vehicles.	Official transportation for expatriate advisors.	USAID
15. Operation, maintenance and repair of vehicles.		GOK
OPERATING CAPITAL		
16. Operating capital for cooperative unions and societies to buy and store grain before selling.	To enable cooperatives to pay farmers cash on delivery of grain to buying centers or cooperative stores.	USAID
EXPATRIATE TECHNICAL ASSISTANCE		
17. One expatriate expert in grain marketing - salary and support for 3 years at beginning of project.	Located in Kisumu. To assist in establishing a grain grading system for use by cooperatives in buying and selling grain. To assist unions in recruiting grains operations managers and store clerks. To train grains operations managers and store clerks.	USAID
18. One expatriate expert in agricultural engineering - salary and support for 2 years at beginning of project.	Also located in Kisumu. To supervise construction and operation of batch grain dryers at cooperative stores. To train grains operations managers and store clerks in the operation of batch dryers.	USAID

qualifications would be A-level education or O-level with experience. USAID would provide salary support to the union only while it was building up grain marketing capability and experience. After the end of project year four, the unions would be expected to pay the salaries of the grains operations manager from the profits of their marketing operations.

The project would also pay the salaries of 37 store clerks (one at each store) for three years each, 21 beginning in project year two to be located at half of each union's stores, and 16 beginning in project year three to be located at the remaining stores. The store clerks would work under the grains operations manager. They would be responsible for receiving and handling grain, grading, assembling into a uniform standard, and applying insecticides to maintain quality in storage. They would also be responsible for the maintenance of good working order of equipment in the store. These individuals would also be full-time employees of the union. Their qualifications would be O-level education. Again, the unions would be expected to pay the salaries of the store clerks from the profits of their marketing operations once USAID assistance terminates.

b. Training

The project would provide 2 three-week training courses for the grains operations managers, an initial course in project year two and a refresher course in year three. Holding two courses would allow for some turnover among the grains operations managers between the two years. The courses would be taught by the two expatriates (provided for below) accompanied by their Kenyan counterparts, the Provincial Marketing Officers of MOCD in Western and Nyanza Provinces.

The project would also provide 3 two-week training courses for 21 store clerks, one in each of project years two, three, and four, again allowing for turnover among the store clerks. These courses would also be taught by the two expatriates and their Kenyan counterparts. The courses in project year four would be taught exclusively by the two PMOs as by this time the expatriates would have left the country.

The courses would be held at the MOCD offices in Kisumu during the off-season. USAID would pay for travel and accommodation for all participants and for instructional materials.

c. Commodities

The project would equip each of the 37 stores with moisture meters, platform scales, grain quality testing equipment, grain cleaning equipment, and drying facilities. Half of each union's stores where store clerks have been recruited would be equipped in the second year of the project and the other half in the third year. No new stores would be built - the objective would be to improve the operating efficiency of existing stores - but an office for the store clerk and a cabinet in which to keep the equipment would be constructed in each store.

The cooperative unions would be expected to operate, repair, and maintain this equipment and to establish a sinking fund to replace it over time. All these costs should be financed from the profits of the cooperative unions' marketing operations.

d. Operating Capital

The cooperative unions would require operating capital to purchase grains on a cash basis. Once the grains operations managers and store clerks have been recruited and trained, and once the cooperative stores have been equipped, the participating unions would receive a loan based on the anticipated amount of maize, beans, and other grains handled. The loan would be advanced by the Cooperative Bank prior to the major buying season and paid back with interest before the beginning of the next season. The Cooperative Bank in turn would be loaned the funds by USAID. (This and other aspects of the unions' marketing operations are discussed further in sections 2 and 3 below).

e. Expatriate Technical Assistance

The project would provide one expatriate grain marketing expert for 3 years and one expatriate agricultural engineer for 2 years to assist MOCD in improving the grain marketing capabilities of the ten cooperative unions in Western and Nyanza Provinces. Both expatriates would report to the chiefof the planning division in Nairobi but be located at the MOCD provincial offices in Kisumu. They would arrive in Kenya midway through project year one.

The responsibilities of the grain marketing expert would be:

- To assist the Ministry of Cooperative Development in establishing a grading system for the purchase of maize, beans, and other grains by cooperative unions/societies.
- To assist cooperative unions in recruiting grains operations managers and store clerks.
- To train the grains operations managers and store clerks in three- and two-week courses respectively.
- To assist the grains operations managers and store clerks in the performance of their duties. This will necessitate a considerable amount of travel to cooperative union facilities throughout Western and Nyanza Provinces.

His qualifications would be a B.Sc. and some developing country experience in grain marketing.

The responsibilities of the agricultural engineer would be:

- to train grains operations managers and store clerks in the operation of the batch dryers supplied to cooperative stores.
- to supervise the construction and operation of the batch grain dryers at cooperative stores.

It is judged that this would be a full-time job for two years. His qualifications would be a degree in agricultural engineering with courses in grain processing; only one year's experience would be required.

f. Expatriate support

The expatriates would have two Kenyan counterparts. These would be the Provincial Marketing Officers of the MOCD in Western and Nyanza Provinces, positions that would be created by GOK under this project. Initially, these personnel would have functions similar to the two expatriates for building up the capability of cooperative unions to market and store grain. Later, they would also become involved in the marketing of other agricultural products by the cooperatives. One of the two positions would be created in project year one and the second in project year two.

The project would provide one vehicle for each expatriate for travelling on official business in Kenya. GOK would provide two full-time drivers and pay for operating, maintenance, and repair of vehicles. GOK would also provide the expatriates with offices, secretarial assistance, and supplies.

2. Grain Marketing and Storage Operations of the Cooperative Unions

Participating unions that have recruited grains operations managers and store clerks and been supplied with grain handling equipment could undertake two kinds of operations: first, they could purchase grain from smallholders (who are their members), assemble it at their stores, and transport it directly to the National Cereals and Produce Board; this is a pure marketing operation. Secondly, they could purchase grain soon after harvest, store it in their stores, and sell it back to farmers or other local customers in the rural areas. The net effect of this is to keep the grain in the rural areas near where it was produced and to moderate the seasonal swings in grain prices on the local market.

At the present time (March 1980), there is no fixed price that unions must pay farmers for their maize. The price that is legally fixed is that of maize delivered to the National Cereals and Produce Board at KSh 87.40 per bag which includes KSh 7.20 for a new gunny bag and a 20 ¢ subsidy for treatment with insecticide. The selling price throughout Western and Nyanza Provinces is KSh 102.90 per bag. As an agent of the NCPB, the cooperative union can also legally sell maize to farmers at this price. The costs and margins for a cooperative union involved in each type of activity - pure marketing vs. marketing and storage - are outlined in Tables VI-7 and VI-8. Through what follows, it is assumed that the union operates one 600 ton store, three 200 ton stores, and employs one grains operations manager and four store clerks. (This represents a rough average for the ten unions in Western and Nyanza Provinces). It is further assumed that maize is the only grain handled by the union.

It is clear that the combined marketing and storage operation is the more profitable, albeit the more risky, from the point of view of the cooperative union. The margin to cover fixed costs on the combined operation is KSh 9.07 per bag compared to KSh 2.34 on the pure marketing operation. (no subsidies are assumed as the union must ultimately operate as a viable economic entity.)

Table VI-7. Pure marketing operation: Costs and margins for representative cooperative union in Western and Nyanza Provinces (KSh per bag of maize)

Price paid to farmer at buying center, lowest grade, 17.5 percent moisture*	KSh 63
Premium for higher grades, or drying and dockage costs	KSh 4
Transport, loading, and unloading, from buying center to cooperative store, to NCPB. Average distance 45 km. @ 20¢ per km.	KSh 9
New gunny bag	KSh 7.20
Insecticide treatment	KSh .60
Cost of maize to cooperative	KSh 83.80
Interest on loan for operating capital - 1.5 percent for two months	KSh 1.26
Cooperative margin to cover fixed costs	KSh 2.34
Price of maize delivered to NCPB depot	KSh 87.40

* Estimated price. Actual price paid farmers would be negotiated between union and district commissioner upon justification of the union's cost. Price paid to farmer would be higher if farmer delivered maize directly to the cooperative store.

Table VI-8. Marketing and storage operation: Costs and margins for representative cooperative union in Western and Nyanza Provinces (KSh per bag of maize)

Cost of maize to cooperative (See previous table)		KSh 83.80
Loss in storage (nine months)*		
Insects	1.65%	
Mold	1.43%	
Total	3.08%	KSh 2.57
Additional insecticide treatments		KSh 1.80
Interest on loan for operating capital 6.75 percent for nine months		KSh 5.66
Cooperative margin to cover fixed costs		KSh 9.07
Price of maize sold at cooperative store		KSh 102.90

* Estimated from actual losses incurred by NCPB at their warehouses over first nine months of storage. Losses calculated from samples collected by team from NCPB depots.

In order to cover all fixed costs on the pure marketing operation alone, it is necessary for the union to handle 32,977 bags of maize or go through 2.75 turns of the stores (assuming 12,000 bags of capacity in the 4 stores combined). On the combined marketing and storage operation, the union can break even by handling only 8512 bags, equivalent to 0.71 turns of the stores. These results are shown in Table VI-9.

It is worth considering why the combined marketing and storage operation is the more profitable. Basically, for the pure marketing operation, the cooperative's four stores, the grains operations managers, and the store clerks are so much dead weight. As the union will only be able to buy maize from farmers at KSh 63 a bag for a couple of months after harvest, the stores and the personnel will be inactive for most of the year. The stores, of course, have already been built. Employing grains operations and store clerks part-time is not judged to be a viable alternative if the union really expects to build up its marketing capability. This involves employing and training key personnel who have the incentive to work for the union full-time.

Probably the most realistic alternative for the union is to market some maize directly to the NCPB while storing other maize for up to nine months for resale to farmers. If the union marketed 12,000 bags (one turn of the stores) directly to the NCPB and stored another 12,000 bags for resale to farmers, they would make a profit of KSh 59,708 over and above their fixed costs, or KSh 2.49 per bag of maize handled. This would provide a comfortable margin to cover the risk involved in storing maize for nine months while the price rises in the local market from below the equivalent of KSh 83.80 a bag to above KSh 102.90 a bag. Indeed, this is judged to be the type of marketing and storage operation at which cooperative unions should aim within the rigidities imposed by the fixed price structure.

3. Requirements and Constraints

Institutionally, it is the responsibility of the Ministry of Cooperative Development to assist cooperative unions to become viable economic agents. Therefore, the project would work through this Ministry in providing support to the ten participating cooperative unions. MOCD would utilize an existing organization or set up a new organization to administer the funds provided by USAID under the project.

In addition, MOCD would have a number of other obligations. First, not all the unions that would be supported under the project are currently agents of the National Cereals and Produce Board for marketing grain, yet under existing marketing legislation, they must be granted this status if they are to expand and improve their involvement in the marketing of grain. The Ministry would take the appropriate action to assist all the affected unions to become agents of the NCPB.

Secondly, the cooperative unions, if they are to purchase grains of varying quality from their members, must be able to implement a grading system for grains. The importance of this cannot be overemphasized if farmers are to have the incentive to produce high quality grain and if the cooperative unions are to make money from their marketing activities in grains, for part of their role would be an assembly function to purchase grain and to dry, clean, and otherwise raise its quality so that it would meet the National Cereals

Table VI-9. Volume of maize handled in order to break even on pure marketing vs. marketing and storage operations: Representative cooperative union in Western and Nyanza Provinces

Sample operation	Pure marketing operation (bags)	Number of turns of stores	Marketing and storage operation (bags)	Number of turns of stores
1.	32,997	2.75	0	0
2.	24,000	2.00	2,321	0.19
3.	18,000	1.50	3,869	0.32
4.	12,000	1.00	5,417	0.45
5.	6,000	0.50	6,964	0.58
6.	0	0.00	8,512	0.71

Fixed costs for the cooperative union are as follows:

Annual salary plus housing allowance for:	
- one grains operations manager	KSh 16,560
- four store clerks	KSh 35,880
Operating, repair, maintenance, and replacement of:	
- grain handling equipment at 10% of initial cost	KSH 2,772
- four cooperative stores at 5% of initial cost	KSh 22,000
Total fixed costs	KSh 77,212

Cooperative margins are KSh 2.34 per bag on pure marketing operation and KSh 9.07 per bag on marketing and storage operation.

and Produce Board standard. Therefore, the Ministry would approach the appropriate authority to obtain permission for the cooperatives to institute a grading system for grains, particularly maize. This grading system should be simple with at most three grades. The base price should be for the lowest quality grain with premiums given for higher quality grain because psychologically farmers would respond more favorably to such a system. It is likely that the cooperatives could receive permission from the appropriate authority to institute such a grading system because, in law, the National Cereals and Produce Board is supposed to operate such a system and, in practice, it is beginning to do so at depots where drying facilities are being installed (Bungoma, Webuye, and Kitale). Once permission has been so obtained, the project would make provision for the expatriate expert on marketing to assist the Ministry in establishing the grading system.

After consultation with MOCD officials, it is judged that there would not be insuperable difficulties in fulfilling either of these obligations. A third obligation, however, presents an entirely different level of difficulty. Under the project, MOCD would be responsible for setting up institutional arrangements by which the Cooperative Bank of Kenya would extend loans for operating capital to the participating cooperative unions. From its own resources, the CBK already does extend produce-buying loans to some of the more solvent cooperative unions. The present terms of these loans are, however, very strict and would preclude the type of marketing and storage operation that unions could pursue most profitably, as discussed in section 2 above. The difficulties are as follows:

- present CBK policy is to require full repayment of produce-buying loans after six months, which would preclude storage in cooperative stores for up to nine months in order to take advantage of fixed price margins. In essence, present CBK policy is to encourage pure marketing, not marketing and storage. The latter is judged not only to be the more profitable operation from the cooperative union's viewpoint but also to have the greatest benefit to smallholder farmers as both sellers and purchasers of maize, and to Kenyan society in reducing transport costs.

- CBK requires some form of collateral for its loans. If the cooperative union were to deliver maize to the NCPB, then the CBK would expect to be repaid its loan directly from NCPB, not via the cooperative union. But present long delays in payment by NCPB to CBK would preclude the cooperative union from receiving additional operating capital to handle maize equal to more than one turn of their stores in one season. As shown in section 2 above, cooperative unions cannot operate viably on this basis. An alternative might be to extend operating capital for the entire amount of maize handled in one season, but for a pure marketing operation, this would increase the amount of operating capital required to break even by 2.75 times. Total USAID assistance to the ten cooperative unions would then increase from an estimated $US 1.4 million to $US 3.8 million.

- CBK policy would permit it to extend produce-buying loans to cooperative unions for greater than 6 months and without collateral if the loans were guaranteed by GOK. But GOK would only guarantee the loan if USAID gave assistance for operating capital on a grant basis. Even on a loan basis - assuming that the above problems could be solved - GOK would require assistance from USAID at approximately 1 percent in order to extend loans to unions at 9 percent. The mark-up by the Treasury is roughly 3 percent and by the CBK roughly 5 percent.

The Kenya National Crop Storage Study Team is not able to recommend concrete solutions to any of these problems.

Finally, MOCD has one further difficulty in agreeing to the project as currently designed. This concerns the regional focus of USAID assistance. MOCD would find it politically difficult to limit the program only to Western and Nyanza Provinces. If USAID does not want to extend the project beyond these areas on its own, then it may be necessary to include other donors such as the World Bank and the EEC into the project design with their assistance going to other regions of the country, before MOCD could put its stamp of approval on the project.

4. Elements and Costs

This section summarizes the material found on Summary Chart VI-4 and on Table VI-10, covering project elements and costs for assisting cooperative unions to improve their grain marketing capability.

a. Kenyan Personnel

During the five years of the project USAID would be expected to subsidize the grain marketing operations of participating unions by paying the salaries of union personnel. Cost to USAID is estimated at $ US 49.2 thousand in project year two, rising to $69.1 thousand in years three and four, and falling to $19.9 thousand in year five. Total USAID life of project costs are estimated at $207.3 thousand.

b. Training

During the five years of the project, USAID would be expected to pay costs to train cooperative union personnel in grain handling. Generally this includes travel and accommodation for participants as well as instructional materials. Total life of project costs to USAID are estimated at $15.4 thousand.

c. Commodities

The cost of commodities supplied to cooperative unions would be expected to be borne exclusively by USAID. Total life of project costs to USAID are estimated at $247.5 thousand, of which $145.3 thousand occurs in project year two and $102.2 thousand in project year three.

Table VI-10. Project component estimated costs: Improving grain marketing capabilities of cooperative unions (1980 prices)

	Project Year 1		2		3		4		5		Estimated 5 year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
KENYAN PERSONNEL (Salaries)												
1.* Grains Operations Managers	---	---	---	23.0	---	23.0	---	23.0	---	---	---	69.0
2. Store clerks	---	---	---	26.2	---	46.1	---	46.1	---	19.9	---	138.3
	---	---	---	49.2	---	69.1	---	69.1	---	19.9	---	207.3
TRAINING												
3. Three-week courses for grains operations managers	---	---	---	2.9	---	2.9	---	---	---	---	---	5.8
4. Two-week courses for store clerks	---	---	---	3.2	---	3.2	---	3.2	---	---	---	9.6
Subtotals	---	---	---	6.1	---	6.1	---	3.2	---	---	---	15.4
COMMODITIES												
5. Grain-handling equipment	---	---	---	113.3	---	86.2	---	---	---	---	---	199.5
6. Operating/repair/maintenance	---	---	---	---	---	---	---	---	---	---	---	48.0
7. Grain-drying facilities	---	---	---	32.0	---	16.0	---	---	---	---	---	---
8. Operating/repair/maintenance	---	---	---	---	---	---	---	---	---	---	---	---
Subtotals	---	---	---	145.3	---	102.2	---	3.2	---	---	---	247.5
9. OPERATING CAPITAL	---	---	---	1,000.9	---	372.4	---	---	---	---	---	1,373.3
EXPATRIATE TECH. ASSISTANCE												
10. Two expatriates	---	150.0	---	300.0	---	225.0	---	75.0	---	---	---	750.0
EXPATRIATE SUPPORT												
11. Kenyan counterparts (Salaries of 2 PMOs)	23.3	---	93.0	---	93.0	---	93.0	---	93.0	---	395.3	---
12. Two vehicles	---	20.0		---	---	---	---	---	---	---	---	20.0
13. Operating/repair/maintenance	11.3	---	30.8	---	38.9	---	38.9	---	38.9	---	158.8	---
14. Two drivers	12.4	---	24.8	---	24.8	---	24.8	---	24.8	---	111.6	---
Subtotals	47.0	20.0	148.6	---	156.7	---	156.7	---	156.7	---	665.7	20.0
GRAND TOTALS	47.0	170.0	148.6	1,501.5	156.7	774.8	156.7	147.3	156.7	19.9	665.7	2,613.5
Estimated Foreign Exchange Component of GOK costs ($US 1,000)	1.6		4.3		5.4		5.4		5.4		22.1	
Estimated costs in current prices inflated at 15% per year	54.1	195.5	196.5	1,985.7	238.3	1,178.4	274.1	257.6	315.2	40.0	1,078.2	3,657.2
Estimated loan component of USAID costs, current prices		46.0		1,376.6		566.4		---		---		1,989.0

*Reference notes on following page.

Notes to Table VI-10

KENYAN PERSONNEL

1. Salaries of ten grains operations managers, one at each union, during project years two, three and four. Salary of KSh 1,200 per month plus 15 percent housing allowance for each manager.

2. Salaries of 21 store clerks, one at each cooperative store, in project years two, three, and four, and an additional 16 store clerks in years three, four and five. Salary of KSh 650 per month plus 15 percent housing allowance for each clerk.

TRAINING

3. Accommodation and travel for ten grains operations managers per course at KSh 90 per day for 19 days each. Instructional materials at $50 per participant. One course held in years two and three. Training courses will be held at MOCD offices in Kismu.

4. Accommodation and travel for 21 store clerks per course at KSh 60 per day for 12 days each. Instructional materials at $50 per participant. One course held in each of years two, three, and four. Training courses will be held at MOCD offices in Kisumu.

COMMODITIES

5. Twenty-one stores equipped in project year two and 16 in project year three. Cost of $3,850 per store. See Table VI-11 for itemization of commodities and cost. Add 40 percent for shipping costs.

6. Cooperative unions will pay these costs from their operating margins. Therefore, this is not a project cost by either GOK or USAID.

7. Two grain dryers for each of eleven 600 ton stores in project year two. One grain dryer for each of ten 200 ton stores in year two, and sixteen 200 ton stores in year three. Cost of $1,000 per dryer. See Table VI-11.

8. This is not a project cost since cooperative unions will pay for these from their operating margins.

OPERATING CAPITAL

9. The ten cooperative unions have 118,000 bags of storage capacity in 37 stores. Cost assumes that operating capital will be given for one turn of the stores at KSh 83.80 per bag which is the cost to unions. Loans given to unions for 86,000 bags in project year two and an additional 32,000 in project year three. Loans given at beginning of one season should be collected by the end of the season for next year.

EXPATRIATE TECHNICAL ASSISTANCE

10. One grain marketing expert and one agricultural engineer at $150,000 per year for all costs. Salary; benefits; transport of family, household goods, personal effects and vehicle; education; post; hardship allowance; housing; per diems; etc. GOK to provide office, secretarial assistance, vehicle (purchased by project), and supplies (paper, pencils, phone, etc.). Grain marketing expert on line from project year 0.5 to 3.5; agricultural engineer from year 0.5 to 2.5.

EXPATRIATE SUPPORT

11. One PMO recruited from project month six, the second from project month twelve. Per person per year, KSh 30,000 salary, plus additional 55 percent for housing allowance, uniform and clothing, and travel and accomodation while on duty.

12. Two 2WD sedan vehicles at $10,000 each (duty-free). Supplied midway through project year one.

13. Gas, oil and tires at $.10 per mile, vehicles travelling 12,000 miles per year (6,000 in project year one). Repairs and maintenance at 3.75 percent of initial purchase cost during first year of vehicle life, and 15 percent during subsequent years.

14. Two drivers on line from midway through project year one to year five. Per driver per year, KSh 8,000 salary plus 55 percent for allowances.

Table VI-11. Equipment list and cost for each MOCD store

	Item description (size/capacity)	Total required	Estimated unit cost	Estimated total cost
			----------$US----------	
	MOISTURE METER			
1.	Portable, solid state operated on VAC/Batteries, for most cereals and pulses	2	850.00	1,700.00
				1,700.00
	GRAIN QUALITY TESTING EQUIPMENT			
2.	Dockage sieves for:	2 sets		
	Wheat and corn		11.85	23.70
	Sorghum		12.00	24.00
	Weevil		11.95	23.90
	Rice		15.20	30.40
	Pan		5.15	10.30
3.	Bag probes, 7/8" outside diameter, 6 openings without partitions, brass chrome plated	1	47.00	47.00
4.	Truck (Lorrie) grain probe, 40" x 1-3/8" Outsider diameter, six openings without partitions, double tube brass	1	78.00	78.00
5.	Bag triers, 1" outside diameter at large end 12" long	6	17.00	102.00
6.	Sample divider, riffle type	1	152.00	152.00
7.	Hand grinder, cast iron	1	52.80	52.80
8.	UV light (Black light) Battery operated with replacement tube	1	99.20	99.20
9.	Sample pans, triangular heavy tin enameled	6	6.55	39.30
				682.60
	SCALES AND BALANCES			
10.	Dockage percentage and computer scale, 1,000 grams capacity with cup	1	461.45	461.45
11.	Platform scale, combination metric and avoidupois	1	444.00	444.00
				905.40
	MISCELLANEOUS EQUIPMENT			
12.	Pallet truck with brakes, solid tires 10", steel frame	2	206.00	412.00
	GRAIN CLEANING EQUIPMENT			
13.	Wood frame, paddle type blower	1	150.00	150.00
				562.00
	GRAIN DRYING FACILITIES			
14.	Batch grain dryer, 2.2 ton capacity, motor or diesel engine driven kerosene or wood heated (corn cobs, stalks, saw dust can also be used as fuel)	1		
	Kerosene Heated Model		1,000.00*	1,000.00
				4,850.00

* wood heated model will cost about 15% more.

d. Operating Capital

The cost of operating capital loaned on a seasonal basis to cooperative unions would be expected to be borne exclusively by USAID. Costs to USAID are estimated at $1000.9 thousand in project year two and $372.4 thousand in project year three for a total life of project cost of $1373.3 thousand.

e. Expatriate Technical Assistance

The cost of expatriate technical assistance would be expected to be borne exclusively by USAID. Costs are estimated at $150.0 thousand in year one, rising to $ 300.0 thousand in year two, and falling to $75.0 thousand in year four. Total life of project costs to USAID are estimated at $ 750.0 thousand.

f. Expatriate Support

During the five years of the project, GOK and USAID would be expected to share costs of expatriate support. Cost to GOK are estimated at KSh 47.0 thousand in year one rising to KSh 156.7 thousand in years three, four, and five. Total life of project costs to GOK are estimated at KSh 665.7 thousand. Total life of project costs to USAID are estimated at KSh 20.0 thousand, all of which occurs in project year one.

g. Total Life of Project Estimated Costs for Cooperative Union Component

Life of project costs for the component are shown year by year in Table VI-10. Total USAID costs are estimated at $2613.5 thousand in constant 1980 prices or $ 3657.2 thousand in current prices.

Of the latter, $ 1989.0 thousand might be suitable for a loan covering the costs of operating capital assistance and construction costs for two houses for the two expatriates. Total GOK costs for this component are estimated at KSh 665.7 thousand in constant 1980 prices or KSh 1078.2 thousand in current prices. Of the former, $22.1 thousand are estimated as foreign exchange costs, which are associated with vehicle operating, repair, and maintenance.

Project Component E: Assistance to Egerton College

1. Project Description

Very limited curriculum capability at Egerton now exists in postharvest subjects: Agricultural Engineering, Crop Science, Entomology, Microbiology and Plant Protection. Egerton would like to expand its curriculum capabilities in postharvest handling and storage and to emphasize these subjects as a part of its current overall expansion. This would be done by adding both coursework and applied research capability in grain storage, handling, movement, processing and protection. Coursework and research capability are to

be added in the Agricultural Engineering, Agronomy, and Biology Departments. The number of students in these three departments is expected to increase from about 800 at present to 1500 by 1983. The emphasized postharvest capability will permit several hundred or all of these students to receive specialized postharvest training. This will translate directly to the farm level as these diploma graduates take up their district and division level positions throughout Kenya. Consultants recommend that the curriculum development, added coursework, and added applied research capability be included, as discussed, in the present project.

Specific assistance recommended for the College includes:

- Participant training for Egerton faculty in the subject areas of Agricultural Engineering, Agronomy (crops), Microbiology, Biology, Mycology, Mammalogy, Entomology, and Plant Pathology.

- Addition of physical plant to the Biology Department's laboratory.

- Provision of equipment to create an Agricultural Engineering Department Crop Processing Laboratory.

- Procurement of technical books and literature for the College library.

USAID is now funding the Egerton College Expansion Project (ECEP), a major project to expand and develop college capabilities in virtually all its subject areas. Numbers of faculty are to go to the United States for participant training, many of these in the subjects required for postharvest emphasis. Substantial quantities of facilities, equipment and materials are to be provided at the College.

It is recommended that the requisite participant training be incorporated into the ECEP (SECID component) now being funded by USAID. New physical plant(insectaries) should be added onto the Biology lab now in existence (or onto new construction being funded by ECEP). The ECEP is constructing a new soils and water agricultural engineering lab. This will vacate the existing lab structure. It is recommended that the current project equip the existing building so that it can be used as a crop processing laboratory. Finally, an annual allowance for technical books and materials is recommended for the College Library.

The Summary Chart VI-5 indicates the quantity, timing, purpose and probable source of funding for each item proposed as assistance to Egerton College.

2. Requirements and Constraints

To add to Egerton the curricula, coursework and applied research capability as recommended, the Egerton College Expansion Project and its SECID component must be fully utilized.

a. Kenya Participants Under SECID

Summary Chart VI-5. USAID and GOK requirements for Egerton College assistance

Quantity, item, timing	Purpose	Probable source of finding
KENYAN PERSONNEL		
1. Two M. Sc. faculty for the Ag. Engineering Department (training underway as of Sept. 1980)	To train Egerton faculty, using the SECID project, for positions which now exist or are to be created under the ECEP project, in postharvest handling and storage subject matter: drying, handling, storages, movement, processing; toxins, mycology entomology, microbiology, plant pathology and taxonomy; as these relate to postharvest grain science.	Existing capability to be developed under the SECID participant training component of the ECEP. Positions now exist.
2. One M. Sc. faculty for the Crop Production Department (training underway as of Sept. 1980)		" " "
3. Two M. Sc. faculty for the Biology Department (training underway as of Sept. 1980): 1 in Entomology, 1 in Microbiology	To develop specific postharvest curricula and coursework for the training of Egerton students in the fields of Ag. Engineering, Agronomy, Horticulture, Food Technology, Biology, Crop Protection, Crop Science, Crop Production, Microbiology, Mycology, Entomology, and Mammalogy (rodents).	" " "
4. 1 Maintenance and repair technician for the Ag. Engineering Crop processing laboratory.1/		GOK
TRAINING		
5. None (to be provided under the SECID participant program)		SECID participants to receive required coursework.
COMMODITIES		
6. 1 insectary-screen room plus 2 insectary-rearing rooms to be added to Biology Department Lab	To provide applied research capabilities and lab. Instruction capability in postharvest subjects.	USAID for all construction costs, GOK for maintenance.
7. 1 set of equipment for the creation of a crop processing lab for the Ag. Engineering Department	" "	USAID for all equipment costs; GOK for maintenance
8. Technical Literature for the College Library	" "	USAID
OPERATING CAPITAL		
None		
EXPATRIATE TECHNICAL ASSISTANCE		
None - To be provided under the SECID program	The expatriates already posted to Egerton under the SECID project are replacing the Egerton faculty now receiving USA training.	SECID expats

1/ This technicians function is to maintain and to instruct upon the use of the equipment in the crop processing lab.

During 1979 and 1980, SECID-ECEP has sent or will send participants to USA for training in the following major subjects: Agricultural Engineering, Agronomy, Horticulture, Food Technology, Biology, Crop Protection and Crop Science. Neither the total numbers of students, the number per major student, nor the split between B.Sc. and M.Sc. degrees is precisely known at this writing (it is known for September, 1979 participants but not yet known for September, 1980 participants). It is recommended that the USAID-SECID Project officer amend the PIO/P for SECID participants as follows: course-work of specific interest is to be taken by participants training in the major fields of interest (see the Summary Chart VI-5 under Kenyan Personnel and Training).

b. Maintenance Technicians for the Crop Processing Laboratory

The head of Egerton's Agricultural Engineering Department has indicated the need to post a maintenance technician in the crop processing laboratory, to maintain the lab's equipment and to teach its use. This new slot should be created and filled at the time the lab is equipped.

c. Timing of Commodity Procurement

While not critical, it is nevertheless suggested that the commodities to be procured in this component - insectaries, lab equipment, and technical literature - be budgeted, with funds committed, during project year one.

3. Elements and Costs for This Project Component

This section summarizes material found on Summary Chart VI-5 and Table VI-12 "Project Component Estimated Costs: Egerton College Assistance". Because of the detail in that material and the very small size of this project component, the present summary is very brief.

New personnel required from GOK is one laboratory equipment maintenance technician, at a total 5-year cost to GOK of KSh 97.7 thousand. Other requisite personnel will be provided through faculty persently in the United States training or, temporarily, from SECID expats.

Egerton commodities include 1 insectary - screen room and 2 insectary-rearing rooms; a set of equipment for a new Agricultural Engineering Department Crop Processing Laboratory, and technical literature for the College library. Total 5 year commodities costs to GOK is estimated at KSh 10,400 and to USAID at $US 38,200.

Total life of project estimated costs for the Egerton College Component

Life of project costs for the Egerton College component are shown year by year and in total in Table VI-12. Total USAID costs for this component are estimated at $US 38,200 in constant 1980 prices or $ 47,800 in current prices. Total GOK costs for this component are estimated at KSh 108,100 in constant 1980 prices or KSh 155,800 in current prices. Of the GOK total less than $US 1,000 are estimated as foreign exchange costs. The latter are associated with operation, repair, and maintenance at the two Egerton laboratories receiving project component assistance.

Table VI-12. Project component estimated costs: Egerton College assistance
(1980 prices)

	Project Year 1		2		3		4		5		Estimated 5 year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
KENYAN PERSONNEL (Salaries)												
1.* 1 Certificate holdings Equipment Maintenance Technician	7.0	---	14.0	---	14.0	---	14.0	---	14.0	---	63.0	---
2. Personnel Support	3.9	---	7.7	---	7.7	---	7.7	---	7.7	---	34.7	---
Subtotals	10.9	---	21.7	---	21.7	---	21.7	---	21.7	---	97.7	---
COMMODITIES												
3. 3 insectaries for Biology Lab.	---	6.9	1.5	---	1.5	---	1.5	---	1.5	---	6.0	6.9
4. Equipment for Agricultural Engin. Crop Processing Laboratory	---	13.3	1.1	---	1.1	---	1.1	---	1.1	---	4.4	13.3
5. Technical Library Literature	---	10.0	---	2.0	---	2.0	---	2.0	---	2.0	---	18.0
Subtotals	---	30.2	2.6	2.0	2.6	2.0	2.6	2.0	2.6	2.0	10.4	38.2
OPERATING CAPITAL												
None												
EXPATRIATE TECHNICAL ASSISTANCE												
None												
GRAND TOTALS	10.9	30.2	24.3	2.0	24.3	2.0	24.3	2.0	24.3	2.0	108.1	38.2
Estimated Foreign Exchange Component of GOK costs in $1,000	---	---	0.2	---	0.2	---	0.2	---	0.2	---	0.8	---
Estimated costs in current prices @ 15% inflation per year	12.5	34.7	32.1	2.6	37.0	3.0	42.5	3.5	48.9	4.0	173.0	47.8

* Reference notes on following page.

Notes to Table VI-12

1. Hired mid-year one. Starting salary KSh 14,000.

2. Estimated at 55 percent of salary and includes housing, clothing, and travel and accommodation while on business in country.

3.

Improvements:	1	2	3	4	5
2 Rearing rooms					
- First Cost ($US)	4.3	---	---	---	---
- Annual (KSh)	---	0.6	0.6	0.6	0.6
Insectary					
- First Cost ($US)	2.6	---	---	---	---
- Annual (KSh)	---	0.9	0.9	0.9	0.9
	$6.9	KSh 1.5	KSh 1.5	KSh 1.5	KSh 1.5

Rearing rooms: 3m x 3m; concrete floor, block walls, trusses, corrugated roof shelving (600 cm depth x 400 cm apart); wiring for lights and fans; no plumbing; 1 room w/windows, 1 room w/no windows, First cost: KSh 1,700/m^2 = KSh 30,600. Annual O, R, and M at 2 percent of First cost = KSh 610.

Screen room = 4.5m x 6m; completely ambient: dirt floor, screen walls, wood frame, one-half screen roof + one-half corrugated roof; no fixtures, no shelves. Tables, shelving, etc., to be carried in and out.

First cost: KSh 700/m^2 x 27m^2 = KSh 18,900. Annual O, R, and M at 5 percent of First cost = KSh 945.

4. Ag. Eng. Crop Processing Lab Equipment

   (a) First cost of equipment: $9,500 as given in Table IV-13. Add 40 percent for shipping costs.

   (b) Annual O, R, and M on equipment: $150, incurred years two to five. See Table IV-13.

5. Budgeted as shown.

Table VI-13. Equipment list and cost for agricultural engineering department, Egerton College

Equipment Description	Year 1	2	3	4	5	Remarks
1. Moisture Determination Equipment and Devices						
1st cost:	3,703.20					Moisture meters, oven, accessories
Operating, repair, maintenance		67.00	67.00	37.00	21.00	
2. Scales and Balances						
1st cost:	1,767.45					Platform scales and laboratory balances
Operating, repair, maintenance		15.00	15.00	15.00	15.00	
3. Grain Quality Testing Equipment						
1st cost:	1,278.20					Sieves, probes, black light, lenses, pans with divider
Operating, repair, maintenance		20.00	20.00	20.00	20.00	
4. Air Property Measuring Equipment						
1st cost:	1,206.20					Includes psychrometers, thermometers, hygrothermograph and accessories
Operating, repair, maintenance		30.00	15.00	15.00	15.00	
5. Miscellaneous Equipment						
1st cost:	447.20					Grinders, shellers
Operating, repair, maintenance		20.00	20.00	20.00	20.00	
6. Temperature Measuring Equipment						
1st cost:	1,100.00					Electronic device
Operating, repair, maintenance		10.00	10.00	10.00	10.00	
$US	9,502.25	162.00	147.00	117.00	101.00	$US 10,029.25

Project Component F:
Assistance to Embu and Bukura Institutes of Agriculture

1. Project Description

The Ministry of Agriculture currently operates Institutes of Agriculture at Embu and Bukura which provide two-year training leading to a Certificate in Agriculture. The team visited both of these Institutes during its field survey, which was followed up by more extensive discussions in Nairobi with the Principal from Embu and a crops production lecturer (representing the Principal) from Bukura. The Institutes occupy a pivotal position in the process of disseminating new agricultural technologies to farmers because they have the primary responsibility for training the TAs who, among the MOA agricultural extension personnel have the most immediate and direct contact with smallholder farmers. Until now, the training of TAs in post-harvest and storage technology has been incomplete. It is the purpose of this component to upgrade the capabilities of Embu-Bukura in this field.

In project component B above, provision is made for in-service training of MOA personnel including TAs who are already employed and working with farmers. These one-week courses held at five regional FTCs in project years two and three are viewed as a stopgap measure until the capabilities of Embu/Bukura have been upgraded.

It is foreseen that Embu/Bukura will play both a training and a development role. There are innovations in the postharvest and storage field that have been developed in other countries that may be applicable to Kenya, but need to be screened and tested in Kenya before they can be recommended to farmers. Embu/Bukura is an appropriate place to do such work for the results can then be disseminated through graduates during their contact with farmers.

One example of such development work concerns grain drying by artificial means. In Benin and Nigeria, a "bush dryer" designed to dry grain in head or shelled form has undergone considerable field trials and is being adopted in various parts of the country. Such a simple design grain dryer may have a practical use in certain areas of Kenya, say, in Meru and Coast Provinces where humidities are very high. The practicality of certain grain dryer designs could therefore be undertaken by Embu/Bukura. As a start, one or the other could test the drying performance of a modified version of the "bush dryer". For more details on the dryer construction, refer to (6).

Under this project component USAID assistance to Embu/Bukura to upgrade their capabilities in the postharvest field will take three forms: training of Kenyan personnel, provision of commodities, and one expatriate for two years with formal training for counterparts. Summary Chart VI-6 indicates the quantity, timing, purpose and probable source of funding for each item proposed.

Summary Chart VI-6. USAID and GOK requirements for assisting Embu/Bukura

Quantity, item, timing	Purpose	Probable source of funding
KENYAN PERSONNEL		
1. Salaries of MOA personnel at Embu/Bukura.	To teach courses in postharvest and storage technology.	No additional financial costs since no new positions created.
TRAINING		
2. Two lecturers and two farm managers for 3-month training program at TPI, England. Lecturers in year two and farm managers in year three.	To receive in-depth training in postharvest handling and storage of grains and pulses.	USAID and GOK
COMMODITIES		
3. Grain quality monitoring equipment, one set for each Institute, supplied in year one.	To be used in teaching the concepts of grain quality.	USAID
4. Teaching aids, one set for each Institute, supplied in year one.	To facilitate the transfer of ideas and concept from teacher to learner.	USAID
5. Operating, repair, and maintenance costs of commodities in 2 and 3 above.		GOK
6. Operating, repair and maintenance costs of expatriate's personal vehicle when used on official business.	Expatriate travel in-country on official business.	GOK
7. Materials for developing and constructing drying and storage units.	To develop and test new postharvest technologies.	GOK
EXPATRIATE TECHNICAL ASSISTANCE		
8. One expatriate, B. Sc. or better: Agricultural Engineering or vocational agricultural lecturer with background in crop processing.	To develop educational curriculum. To handle teaching duties. To assist in development and testing work.	USAID

a. Staff Training

One lecturer and one farm manager from each Institute will be sent to the 3-month training course at TPI, Slough, England, on the storage of durable agricultural products in the tropics. The lecturers will go in project year two and the farm managers in year three. Here they will receive in-depth instruction in aspects of postharvest handling and storage including insect and rodent control so that they themselves will be capable of teaching a similar course to students. An alternative might be the training of existing faculty through an M.Sc. Degree at Nairobi.

b. Commodities

The project will provide the grain quality monitoring and teaching equipment to both Embu/Bukura to assist the staff in teaching the concepts of grain quality, as given in Table VI-15.

It is recommended that all commodities be supplied in project year one.

c. Expatriate Technical Assistance

The project will also provide technical assistance in the form of one expatriate for two years who will spend half his time at each Institute. This should be a B.Sc. or better, either an agricultural engineer with a major in crop processing, or an vocational agriculture lecturer with a background in crop processing, and with three years experience. His responsibilities will be the following:

- to develop a curriculum in postharvest and storage technology suitable for teaching at Embu/Bukura.

- to handle teaching duties until the two lectures have returned from their 3-month courses at TPI.

- to assist in the development and testing of artificial dryers and other postharvest and storage technology.

It is anticipated that this expatriate will liase with the PHSO and SPPO in the postharvest and storage section of MOA. The curriculum developed should be similar to that for the one-week in-service training courses at FTCs, Component B.

In order to reduce the costs of expatriate assistance, it has been suggested that the individual at Embu/Bukura be a Peace Corps Volunteer. It is agreed that this possibility should be explored but, based on past experience in trying to recruit agricultural engineers, it is felt unlikely that the individual required can be recruited through Peace Corps.

2. Requirements and Constraints

This component will be administered by MOA who will have the following obligations under the project. It will release the four Kenyan staff

Table VI-15. Estimated equipment needs each for Bukura and Embu institutes of agriculture institutes

	Item description (size/capacity)	Total required	Estimated unit cost	Estimated total cost
			---------$US----------	
	MOISTURE TESTING EQUIPMENT			
1.	Moisture meter, portable capacitance type, 220 VAC/Bat	2	250.00	500.00
				500.00
	GRAIN TESTING EQUIPMENT			
2.	Dockage sieves for wheat, corn, rice and sorghum with bottom pans	2 sets	55.70	111.40
3.	Balance scales, dial type, 2600 gm capacity, 0.1 gram sensitivity	2	131.00	262.00
4.	Magnifying glass with base	6	24.95	99.80
5.	U.V. Light w/batteries	1	91.40	91.40
6.	Sample divider, riffle type	1	152.00	152.00
7.	Hand grinder, cast iron	1	52.80	52.80
				769.40
	MISCELLANEOUS EQUIPMENT			
8.	Sling psychrometer with spare thermometers and slide rule for psychrometer	2	35.20	70.40
9.	Dial thermometers, 32-100°C 1 3/4" dial, 8" steam	5	15.00	75.00
10.	Bag probes, 7/8" outside diameter i.e., openings w/partitions brass, chrome plated	1	47.00	47.00
11.	Bag triers, 1" outside diameter at large end, 12" long	3	17.00	51.00
12.	Air oven, 220 volts, 1000 Watts 0-300°C	1	648.00	648.00
13.	Forcepts	12	300.00	36.00
14.	Aluminum dishes 2 1/2diameter flat bottom, 3/4" depth w/ cover	3 doz.	1.30	46.80
				974.20
	CLASSROOM EQUIPMENT			
15.	Overhead projector, w/spare bulbs	2	530.00	1,060.00
16.	Slide projector, 220 VAC	1	300.00	200.00
17.	Movie projector, 220 VAC, 16mm	1	700.00	700.00
				1,960.00
				$US 4,203.60

members of Embu/Bukura for training at TPI and pay 80 percent of their salary while in training. It will be responsible for the operating, repair, and maintenance of equipment supplied to the Institutes. Finally, it will provide resources for the development and testing work initiated under this project and continued after the one expatriate leaves the country.

3. Elements and Costs

This section summarizes the material found on summary chart VI-6 and on Table VI-14, covering project elements and costs for assistance to Embu/Bukura.

a. Kenyan Personnel

This is not included as a project cost because no new positions will be created within MOA or any other government agency under this component. However, it does represent a GOK contribution in the form of salaries of MOA personnel involved in this component.

b. Staff Training

The cost of short-term overseas training is expected to be shared by GOK and USAID. Generally GOK will pay one-way air fare to England and USAID will pay all other costs. Cost to GOK is estimated by KSh 13.6 thousand in each of years two and three for a total life of project cost of KSh 27,200. Cost to USAID is estimated at $US 9.6 thousand in each of years two and three for a total life of project cost of $US 19.2 thousand.

c. Commodities

During the five years of the project, GOK and USAID are expected to share cost for commodities to equip Embu/Bukura with grain quality monitoring equipment and teaching aids. Generally, USAID will pay the initial cost of purchasing the commodities while GOK will pay for operating, repairing and maintaining them. GOK will also pay the operating expenses of the expatriate's personal vehicle while used on official business and the cost of the materials for the drying and storage units used in development and testing work at Embu/Bukura.

Cost to GOK is estimated at KSh 6.4 thousand in year one, peaking at KSh 14.3 thousand in year two, and declining to KSh 11.4 thousand in years four and five. Total GOK costs over the life of the project are estimated at KSh 56.3 thousand.

d. Expatriate Technical Assistance

The cost of one expatriate for 2 years is expected to be borne entirely by USAID (Exception: office space, secretarial assistance, telephone, supplies). Total life of project costs for 2 man years of expatriate service is estimated at $US 300 thousand.

e. Total Life of Project Estimated Costs for Embu/Bukura Component

Life of project costs for the Embu/Bukura Component are shown by year in Table VI-14. Total USAID costs for this component are estimated at $ 331.00 thousand in 1980 prices or $ 439.6 thousand in current prices. Of the latter, $49.5 thousand would be suitable for a loan which covers the cost of constructing one house for the expatriate. Total GOK costs are estimated at KSh 83.5 thousand in 1980 prices or KSh 127.3 thousand in current prices. Of the former only $ 1.6 thousand are estimated as foreign exchange costs which are associated with operating, repair, and maintenance of commodities.

Project Component G
Assistance to the University of Nairobi (excluding Research)

1. Project Description

The University of Nairobi is the primal institute of higher education in Kenya and at present the only degree-granting institution in the country. Project component A relies on the University to provide seven degree-holders for headquarters and one for each of six provinces.

There are four departments at the University in fields related to postharvest handling and storage of food grains and legumes. These are Agricultural Engineering, Crop Science, Food Technology and Zoology (which includes a sub-department of Antomology). After consultation with University faculty, it is recommended that, apart from supporting research in each of these departments, the agricultural engineering department is the only one which should be assisted materially in order to build up its teaching capability. This is the weakest of the four departments concerned, having only one lecturer (an expatriate) in the field of crop processing, the potential of one Kenyan returning from overseas training in 1981, and a complete lack of equipment appropriate for teaching and research in postharvest and storage technology. It is two to three years away from offering an M.Sc. in agricultural engineering, unlike the department of Zoology-Entomology which already offers an M.Sc. program.

It is recommended that the Agricultural Engineering department be assisted in two ways. First, during project years one and two, it will be provided with commodities appropriate for teaching and research in the field of postharvest and storage technology. This includes moisture determination equipment, scales and balances, grain quality testing equipment, air property measuring equipment, temperature measuring equipment, and some miscellaneous equipment.

Secondly, the department will be provided with one expatriate lecturer for three years - an agricultural engineer with M.Sc. or better and with experience in crops processing. The responsibilities of this expatriate will be twofold:

Table VI-14. Project component estimated costs: Assistance to Embu/Bukura (1980 prices)

	Project Year 1		2		3		4		5		Estimated 5 year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
KENYAN PERSONNEL												
1.* Nil	---	---	---	---	---	---	---	---	---	---	---	---
TRAINING												
2. Four Kenyans to 3-month TPI Course	---	---	13.6	9.6	13.6	9.6	---	---	---	---	27.2	19.2
COMMODITIES												
3. Grain quality monitoring equipment and teaching aids	---	11.8	---	---	---	---	---	---	---	---	---	11.8
4. Operating/repair/maintenance	---	---	1.4	---	1.4	---	1.4	---	1.4	---	5.6	---
5. O.R.M. for expat. vehicle	1.4	---	2.9	---	1.4	---	---	---	---	---	5.7	---
6. Drying and storage units	5.0	---	10.0	---	10.0	---	10.0	---	10.0	---	45.0	---
Subtotals	6.4	11.8	14.3	---	12.8	---	11.4	---	11.4	---	56.3	---
7. One expat. for two years	---	75.0	---	150.0	---	75.0	---	---	---	---	---	300.0
GRAND TOTALS	6.4	86.8	27.9	159.6	26.4	84.6	11.4	---	11.4	---	83.5	331.0
Estimated foreign exchange Component of GOK costs in $US 1,000	0.2		0.6		0.4		0.2		0.2		1.6	
Estimated costs in current prices at 15% inflation per year	7.4	99.8	36.9	211.1	40.2	128.7	19.9	---	22.9	---	127.3	439.6
Estimated loan component of USAID costs, current prices		23.0		26.5		---		---		---		49.5

Reference Notes

1. Government of Kenya contribution includes salaries of MOA personnel at Embu/Bukura. This is not included as a project cost because no new positions will be created under this component.
2. Two trainees year 2; two more year 3. Cost per trainee (1980 basis): Training fee: £75/week x 13 weeks = $2,243. Return Air fare NBO-LHR: KShs 13,600 = $944 x KSh 6,800 (GOK pays one-half). Accomodation, food, UK transport, pocket money: £235/month x 3 = $1,622. (Note: KSh 7.20 = $1.00 = £0.435).
3. Both Institutes equipped year one. Cost of $4,204 per Institute. See Table VI-15. Add 40 percent for shipping costs.
4. $100 per Institute each year after acquisition of equipment.
5. Expat to use own personal vehicle, reimbursed for O.R. & M. at 20¢ per mile. Average of 2,000 miles travelled per year on official business.
6. KShs 5,000 per Institute per year. KSh 2,500 in project year one.
7. One expat at $150,000 per year for all costs. Salary; benefits; transport of family, household goods, personnel effects and vehicles; education, post, hardship allowance; housing; per diems; etc. GOK to provide office, secretarial assistance, and supplies (paper, pencils, phone, etc.). Expat on line from project year 0.5 to 2.5.

- to teach crop processing to undergraduates including grain drying and storage. This will involve the development of courses and curricula in cases where they do not yet exist.

- to promote the M.Sc. program in crop processing. This will involve recruiting students, assisting in the development of research projects, and finding appropriate research funds (some of which are provided for in project component I.)

The expatriate will not have specific research responsibilities except to advise graduate students in the conduct of their research.

2. Requirements and Constraints

This project component will be administered by the University of Nairobi, who will provide space for commodities given under the project to be housed and used as well as office space, secretarial assistance, and supplies for the expatriate agricultural engineer.

3. Elements and Costs

This section summarizes the material found on Table VI-16 covering project elements and costs for assistance to the University of Nairobi.

Commodities

USAID and GOK will share the cost of commodities, USAID being responsible for the initial cost and GOK for operating, repairing, and maintaining them. Cost to USAID is estimated at $11.1 thousand in each of years one and two for a total life of project cost of $22.2 thousand. Cost to GOK is estimated at KSh 1.4 thousand in year one, peaking at KSh 10.9 thousand in year three, and falling to KSh 8.0 thousand in year five. Total GOK life of project costs for commodities are estimated at KSh 36.6 thousand.

Expatriate Technical Assistance

The cost of one expatriate for 3 years is expected to be borne entirely by USAID (Exception: office space, secretarial assistance, telephone, supplies). Total life of project costs for 3 man years of expatriate service is estimated at $450.0 thousand.

Total Life of Project Estimated Costs for University of Nairobi Component

Life of project costs for the University of Nairobi component are shown by year in Table VI-16. Total USAID costs for this component are estimated at $472.2 thousand in 1980 prices or $671.4 thousand in current prices. Total GOK costs are estimated at KSh 36.6 thousand in 1980 prices or KSh 65.1 thousand in current prices. All of this, equivalent to $5.1 thousand in 1980 prices, is estimated to require foreign exchange as it covers the operating, repair, and maintenance of commodities.

Table VI-16. Project component estimated costs: Assistance to University of Nairobi (1980 prices)

	Project Year 1		2		3		4		5		Estimated 5-year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
KENYAN PERSONNEL												
Nil	---	---	---	---	---	---	---	---	---	---	---	---
COMMODITIES												
1. For agricultural engineering department	---	11.1	---	11.1	---	---	---	---	---	---	---	22.2
2. Operating/repair/maintenance	---	---	4.0	---	8.0	---	8.0	---	8.0	---	28.0	---
3. O.R.M. for expat vehicle	1.4	---	2.9	---	2.9	---	1.4	---	---	---	8.6	---
Subtotals	1.4	11.1	6.9	11.1	10.9	---	9.4	---	8.0	---	36.6	22.2
EXPATRIATE												
4. One expat for 3 years	---	75.0	---	150.0	---	150.0	---	75.0	---	---	---	450.0
GRAND TOTALS	1.4	86.1	6.9	161.1	10.9	150.0	9.4	75.0	8.0	---	36.6	472.2
Estimated foreign exchange component of GOK costs (1,000)	0.2		1.0		1.5		1.3		1.1		5.1	
Estimated costs in current prices at 15% inflation per year	1.6	99.0	14.4	213.1	16.6	228.1	16.4	131.2	16.1	---	65.1	671.4
Estimated loan component of USAID costs, current prices		23.0		26.5		---		---		---		49.5

Reference Notes

1. A total of $15.9 thousand in equipment to be supplied one-half in year one and one-half in year two. See Table IV-17. Add 40 percent for shipping costs.

2. Estimated at 5 percent of initial equipment cost in each year after acquisition of equipment.

3. Expat to use personal vehicle, reimbursed for O.R. & M. at 20¢ per mile. Average of 2,000 miles travelled per year on official business.

4. One expat at $150,000 per year for all costs: Salary; benefits; transport of family; household goods; personal effects and vehicles; education; post; hardship allowance; housing; per diems, etc. GOK to provide office, secretarial assistance, and supplies (paper, pencils, phone, etc.). Expat on line from project year 0.5 to 3.5.

Table VI-17. Equipment list for agricultural engineering department, faculty of agriculture, university of Nairobi

Item description (size/capacity)	Total required	Estimated unit cost	Estimated total cost
		----------$US----------	
MOISTURE DETERMINATION EQUIPMENT			
1. Capacitance type for most cereals 220 VAC	2	775.00	1,550.00
2. Distillation type moisture tester w/ 220 VAC heater, flasks and accessories	2	513.00	1,026.00
3. Air oven with three shelves 220 VAC 1000 watts, o°-3000°C	1	328.00	328.00
		648.00	648.00
			3,552.00
SCALES AND BALANCES			
4. Balance scales, dial type 2600 gm capacity, 0.1 gm sensitivity	2	131.00	262.00
5. Grain scale w/ weight sets of 2 kg, 1 kg, 500 grams	1	1,062.00	1,062.00
6. Platform scales, metric/ English combination 1-500 kg capacity	1	444.00	444.00
			1,768.00
GRAIN QUALITY TESTING			
7. Grain probe for ear maize	2	58.00	116.00
8. Bin, bag, feed, cereal probe 1 3/8" outside diameter with 5 openings brass, no partition	2	78.00	156.00
9. Bag triers, nickle plated, 1" outside diameter at large end	4	16.00	64.00
10. Dockage sieves for wheat, corn, rice and sorghum with bottom pans	2 sets	56.00	112.00
11. Boerner sample divider w/ two pans	1	413.00	413.00
12. Sample pans, triangular	6	6.67	40.00
13. Sample pans, aluminum with spouts	6	16.00	96.00
14. Tyler sieves, 8" diameter, 1 1/8" height Nos. 4, 6, 8, 10, 14, 20, 28, 35, 48, 65, 100, 150, 200, pan, brass material	1 set	337.00	337.00
15. Same as item 14 but with sieve height of 2 7/8"	1 set	337.00	337.00
16. Sieve shaker, 220 VAC 50 cycle 1450 rpm with timer	1	1,030.00	1,030.00
17. Magnifying glasses with base	4	25.00	100.00
			2,801.00
AIR PROPERTY MEASURING EQUIPMENT			
18. Sling psychrometers	6	23.50	141.00
replacement thermometers	6	8.50	51.00
slide rule chart	6	3.33	20.00
19. Hygrothermographs and accessories, pens, charts, inks, etc.	2	623.50	1,247.00
20. Portable aspirating-type psychrometer, battery operated	1	500.00	500.00
			1,959.00

(Continued)

Table VI-17 (Continued)

	Item description (size/capacity)	Total required	Estimated unit cost	Estimated total cost
			----------$US----------	
	MISCELLANEOUS EQUIPMENT			
21.	Hand grinder	2	53.00	106.00
22.	Mechanical maize sheller	2	52.00	104.00
23.	Inclined manometer, 0.1 inch sensitivity with case	1	150.00	150.00
24.	U-tube manometers, 18" long	2	20.00	40.00
25.	Bag trucks, two wheel	2	119.00	238.00
				638.00
	TEMPERATURE MEASURING EQUIPMENT			
26.	Dial thermometers, 0-100°C 1 3/4" dial, 8" stem	10	15.00	150.00
27.	Digital potentiometer, T.C. Wire	2	550.00	1,100.00
28.	Selector switches, 36 points for T.C. wire	2	80.00	160.00
29.	Temperature recorder, 24 points o°-150°C temperature range, T.C. wires	1	3.000.00	3,000.00
30.	Hot wire anemometer	1	800.00	800.00
				5,210.00
			TOTAL	15,928.00

Project Component H:
Assistance to Central Bureau of Statistics

1. Project Description

This project lacked the time to make a complete survey of farm grain storage losses throughout Kenya over an extended time. More extensive data over a period of years would provide more accurate data to plan and evaluate programs aimed at reducing grain storage losses.

The most satisfactory and cost-efficient way of conducting such surveys would be to make them a part of the ongoing series of integrated rural surveys conducted by the Central Bureau of Statistics. The Bureau would agree to do this at the request of the Ministry of Agriculture, but they would require additional resources in order to do it. The purpose of the present project component is to provide the incremental resources required.

It is envisaged that a first loss survey will take place in 1982-83 in the second and third years of the project. A second loss survey will then take place in 1985-86 during the fifth and final year of the project. Together the two surveys will provide baseline and end-of-project data in order to evaluate the impact of the project over the time period. They will also institutionalize the capability of the MOA and the Bureau to conduct surveys of this kind.

In each survey, CBS enumerators will perform the field work including collecting samples, taking moisture readings, killing the insects in the sample, and placing the sample in a plastic bag. Then the samples will be transported to the laboratory in the Post-Harvest and Storage Section of the Ministry of Agriculture where they will be analyzed for insect damage, mold damage, and the presence of aflatoxin. Finally, the results of the laboratory analysis will be sent back to CBS for tabulation, analysis, and publication.

The PHSS laboratory will be equipped to handle approximately 10,000 samples in one year, assessing them for insect and mold damage and screening them for the presence of aflatoxin, as described in Chapter III. B. of this report. Therefore it will not be possible to collect samples from all respondents in the Bureau's national sample in all cycles of the survey.

As an alternative, it is recommended that 5 samples of maize and 3 samples of beans be collected from 5-8 respondents in each of 150 clusters throughout the country, once in each of 12 months of the year (corresponding to one cycle of the survey). This will constitute a maximum of 14,400 samples but allowing for the fact that some households will not have grain in store at the time of each visit, this number will probably be reduced to about 10,000 samples. The Bureau will be responsible for deciding from which

respondents in which clusters to sample grain. It may be deemed desirable to conduct a preliminary questionnaire sometime in 1981-82 of all respondents in the national sample and then to select a representative sample of respondents based on criteria such as:

- amount of grain produced
- type of drying practices used
- type of storage facilities used
- whether grain is stored as threshed or unthreshed
- use of insecticides

a. Staffing Training

In the process of helping the team conduct its survey, the CBS staff at headquarters gained considerable expereience in conducting a grain loss survey of the kind proposed. However, there is still a need for them to receive additional short-term overseas training in activities relating to the survey, especially when it comes to analyzing the loss data that comes from the PHSS laboratory. It is recommended that in project year one, two CBS staff from headquarters attend the seven-week course in grain storage and marketing offered at Kansas State University by the Food and Feed Grain Institute. This will teach them the fundamentals of grain storage and the measurement of losses. It will also teach them aspects of grain marketing that will be of benefit to them in the Bureau's ongoing work relating to grain marketing in Kenya.

Turning to the field staff, it will also be necessary for the project to train the enumerators and supervisors for the 150 clusters from which grain samples will be collected. This training will be conducted by the Grain Quality Specialist in charge of the PHSS laboratory in 2-day sessions with the enumerators and supervisors, one session in each of the six provinces. These should take place during the first six months of 1982. The enumerators and supervisors will be taught the following:

- how to select a representative ½ kg. sample of maize and beans
- how to place the sample in a plastic bag
- how to take the moisture content of the sample
- what additional information to collect concerning the sample, namely,
    (1) name of enumerator
    (2) number of household and cluster
    (3) date collected
    (4) harvest date of the sample
    (5) type of grain - maize or beans
    (6) form in which sampled - ear with husk, ear without husk, pod, or shelled
    (7) type of storage - crib, house, basket, drum, gourd, bag, debe, other
    (8) whether treated with insecticide - if possible, what type and when.

- how to kill the insects in sample, including larvae hidden in the grain, using ethyl acetate. This chemical is an ether which is recommended because it emits a gas which penetrates the grain, because it is non-toxic to humans, and because it is locally available. The objective of the exercise is to protect the sample because it may be 1-3 months before the particular sample is analyzed in the PHSS laboratory.

b. Commodities

Each enumerator will be provided with the necessary equipment to perform these tasks. This includes:

- one moisture meter
- plastic bags
- labels
- ethyl acetate in metal containers
- money with which to purchase the samples of grain

These will be obtained before the 1982-83 survey begins. It will probably be necessary to replace half the moisture meters for the 1985-86 survey as well as all the other equipment.

2. Requirements and Constraints

This project component will be administered by the Central Bureau of Statistics who will have the following obligations. First, the Bureau will be responsible for selecting the respondents in their national sample from whom to collect samples of maize and beans on a regular basis. Secondly the Bureau's enumerators will as a matter of course be visiting the smallholders in the sample once a month in order to collect data on production, sales, and storage of food crops. In addition, they will now be required to collect samples of maize and beans from these respondents. Thirdly, although funds will be provided for the purpose, the Bureau will be responsible for transporting the grain samples to the PHSS laboratory. Finally, the Bureau will tabulate, analyze, and publish the results that come from the laboratory. The whole exercise will involve some re-allocation of staff time within the Bureau.

3. Elements and Costs

This section summarizes the material found in Summary Chart VI-7 and Table VI-18, covering project elements and costs for assistance to the Central Bureau of Statistics.

a. Kenyan Personnel

This is not included as a project cost because no new positions will be created within CBS or any other government agency under this component. However, it does represent a GOK contribution in the form of salaries of personnel involved in this component.

Summary Chart VI-7. USAID and GOK requirements for assisting CBS

Quantity, item, timing	Purpose	Probable source of funding
KENYAN PERSONNEL		
1. Salaries of CBS personnel involved in project.	To collect samples. To tabulate, analyze, and publish loss data.	No additional financial cost because no new positions created.
TRAINING		
2. Two Kenyans for overseas training at Kansas State for 7 weeks each, project year one.	To train two personnel from CBS headquarters in the tabulation and analysis of loss data obtained from laboratory analysis of samples.	USAID and GOK
3. On-the-job training for 150 enumerators and 75 supervisors in postharvest terminology, collection of samples, taking of moisture content and killing insects in the samples. Once in year two and secondly in year five.	To train enumerators and supervisors so that they are capable of conducting the field work involved in the survey. Training will be done by Grain Quality specialist in charge of the laboratory in the Post-Harvest Storage Section.	USAID
COMMODITIES		
4. 150 sets of the following equipment, one for each enumerator, years two and five. a. Moisture meter b. Chemicals for killing insects c. Plastic bags and labels for grain samples	To assist enumerators in conducting their field work.	USAID
5. Money to purchase samples from smallholders, plus transportation of samples to Nairobi.	To pay smallholders.	USAID

Table VI-18. Project component estimated costs: Central Bureau of Statistics (1980 prices)

	Project Year 1		2		3		4		5		Estimated 5-year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
KENYAN PERSONNEL												
1. Nil	---	---	---	---	---	---	---	---	---	---	---	---
TRAINING												
2. 2 Kenyans-K. State Univ. course	18.7	10.2	---	---	---	---	---	---	---	---	18.7	10.2
3. 150 enumerators & 75 supervisors	---	---	---	6.0	---	---	---	---	---	6.0	---	12.0
Subtotals	18.7	10.2	---	6.0	---	---	---	---	---	6.0	18.7	22.2
COMMODITIES												
4. Moisture meters	---	---	---	16.8	---	---	---	---	---	8.4	---	25.2
5. Chemicals	---	---	---	5.3	---	---	---	---	---	5.3	---	10.6
6. Plastic bags, labels, etc.	---	---	---	6.0	---	---	---	---	---	6.0	---	12.0
7. Cost of samples + transportation	---	---	---	9.7	---	---	---	---	---	9.7	---	19.4
Subtotals	---	---	---	37.8	---	---	---	---	---	29.4	---	67.2
GRAND TOTALS	18.7	10.2	---	43.8	---	---	---	---	---	35.4	18.7	89.4
Estimated costs in current prices at 15% inflation per year	21.5	11.7	---	57.9	---	---	---	---	---	71.2	21.5	140.8

Reference Notes

1. GOK contribution includes salaries of CBS personnel. This is not included as a project cost because no new positions will be created under this component.
2. Two trainees in year one. All inclusive cost of $3,765 per trainee plus $2,600 air fare of which GOK pays one-half.
3. Two-day sessions for 150 enumerators and 75 supervisors in each of years two and five. Cost of travel and accomodation is KSh 80 per day per enumerator and KSh 130 per day per supervisor.
4. Handheld digital moisture meters for 150 enumerators in year two; one-half replaced in year five. (Manufactured by Dickey - John). Cost is $80 each, plus 40 percent for shipping costs.
5. Two liters of ethyl acetate in ½-liter non-corrosive metal cans for 150 enumerators in each of years two and five. Available locally at KSh 64 per half liter.
6. Cost of $40 per enumerator, years two and five.
7. Ten thousand samples in years two and five, of which two-thirds maize and one-third beans. Cost of KSh 2 per maize sample and KSh 3 per bean sample. Transportation to Nairobi estimated at twice the cost of the samples.

b. Staff Training

The cost of training is expected to be shared by GOK and USAID. GOK will pay one-way airfare for two trainees to the USA and USAID will pay all other costs, including that of training the enumerators and supervisors in sample collection. Life of project costs to GOK are estimated at KSh 18.7 thousand, all of which occurs in year one. Life of project costs to USAID are estimated at $22.2 thousand.

c. Commodities

Cost of commodities is expected to be borne entirely by USAID. This amounts to $37.8 thousand in year two and $29.4 thousand in year five for a total cost of $67.2 thousand.

d. Total Life of Project Estimated Costs for CBS Component

Life of project costs for the CBS component are shown year by year in Table VI-18. Total USAID costs for this component are estimated at $89.4 thousand in 1980 prices or $140.8 thousand in current prices. Total GOK costs are estimated by KSh 18.7 thousand in 1980 prices or KSh 21.5 thousand in current prices.

Project Component I
Research

1. Project Description

Previous chapters have devolved at length the team's activities and exposure in the study of grain handling and storage in Kenya. Chief among these activities have been the national survey and the scores of discussions with Kenyan functionaries involved with grain handling and storage. These activities, combined with many years experience with these subjects brought to the project by the team, have identified the need for applied research in Kenya on a number of important grain handling and storage topics.

A list of such topics meriting research is presented in Table VI-19. The list is presented in a specific order. Topics 1 to 7 are short-term topics that would be suitable for an M.Sc. student at the University of Nairobi. Topics 8 to 12 are longer-term topics requiring the time and expertise of a senior researcher either at the University of Nairobi or at one of the National Agricultural Research Stations. This division leads the consultants to recommend that USAID fund, with GOK concurrence and support, two types of research programs: short-term grants to M.Sc. students and long-term grants to senior researchers aided either by graduate students or by assistants. All these topics can be conducted using existing Kenyan institutions and research personnel. The consultants also considered the possibility of institutionalizing a permanent, ongoing post-harvest research capability at one of the national agricultural research stations, but, owing to the costs of such a program, it is not possible to recommend such an activity within the existing budget constraints.

Table VI-19. Directions for research on postharvest handling and storage of food grains and legumes in Kenya

1. Intensive research on the use of diatomite and pumice (blue) as insecticides for protecting grains:

   (a) combinations of different grades;
   (b) combinations with suitable toxicants such as pyrethrum;
   (c) dosage levels to achieve protection of maize;
   (d) application procedures which give best results, such as heavy dusting and layering.

2. Research on the effectiveness of ashes when used as stored grain insecticides, and what kind of ashes (i.e. different wood species and rice hulls), if any, are most effective.

3. Research on attractants for the various species of stored product pests and the use of attractants (baits) combined with chemosterilants.

4. Research on small volume air-tight storage (concrete, mud, and pottery jars, metal drums, sealant treated gourds) which are suitable for storage of farm-size lots of grains. The development of molds, insects, toxins, and other grain pathogens; moisture translocation; container effects such as different types of closures; and effect of all these on weight and quality losses of stored grains.

5. Research on direct-fired grain dryers and their merits compared to traditional methods such as smoking.

6. Research on the effect of smoking grain on the grain drying process, on insect protection in stored grain, on palatability and on nutritional value.

7. Research on the cooking and nutritional quality of grain treated with various insecticides.

8. Research program on rearing parasitoids and pathogens for use in the control of storage pests. Mass releases of parasitoids and pathogens in sprays or dusts, etc. Establishment of mass rearing centers and distributional network.

9. Research program on the de-toxification of aflatoxin contaminated grain with emphasis on ammonia and soyabean-urea treatment combinations.

10. Research program on the relative resistance of different cultivars of maize, beans, sorghum, millet, and peas to attack by common postharvest pests: molds, insects, birds, rodents, and toxins. This involves the controlled growing of the cultivars of interest, their controlled infestation, and the measurement of varietal resistance to infestations.

11. Exhaustive and controlled research on grain losses between physiological maturity and storage. Losses from molds, insects, birds, and rodents to be studied on carefully designed and experimentally controlled plots.

12. Intensive research on the drying and storage characteristics of maize, beans, sorghum, millet, and peas when stored in cribs of varying configuration (length-width combinations). Research interest to include insects, molds, and moisture translocation. All types of cribs to be studied, including improved designs, and traditional designs in common use in different regions of the country.

a. Short-term Grants to M.Sc. Students

Research leading to the award of 10 Masters degrees is to be grant-funded at the University of Nairobi. Such grants will be given for topics that can be adequately researched and written up in two years time. It is proposed to grant-fund the entire cost of the 10 students for a 2-year period, including tuition, books, subsistence, and research materials. The research is to be done by Kenyan citizens resident in Kenya and to be supervised by permanent Kenyan faculty members. The topics (Table VI-19) University departments involved, and number of students are as follows:

Thesis topic	Department	Number of students/ theses
(1) Use of diatomite and blue pumice as insecticides.	Zoology-entomology	2
(2) Effectiviness of ashes as insecticides.	Zoology-entomology	1
(3) Attractants and chemosterilants for stored product pests.	Zoology-entomology	1
(4) Small volume air-tight storage: entomological aspects.	Zoology-entomology	1
(5) Small volume air-tight storage: agricultural engineering aspects.	Agricultural Engineering	1
(6) Direct-fired grain dryers, (Student will want to liase with personnel doing related work at Embu/Bukura Institutes).	Agricultural Engineering	1
(7) Effect of smoking grain: agricultural engineering aspects.	Agricultural Engineering	1
(8) Effect of smoking grain: nutritional aspects	Food technology	1
(9) Cooking, palatability, and nutritional quality of treated grain.	Food technology	1

b. Long-term Grants to Senior Researchers

Research leading to published journal articles or to other published results is to be grant-funded at the University of Nairobi, at the National Horticultural Research Station (Thika), and at the National Agricultural Laboratories (Kabete). The topics of interest require longer term research than would ordinarily be undertaken by an M.Sc. or Ph.D. student. Rather, the research will be done by Kenyan staff professors or researchers at the three institutions.

Hence funding for 4 and one-half years of the project, beginning mid-way through project year one, is proposed for each of the six grants. Grants given to the University of Nairobi will cover the researcher's full-time salary, 2 M.Sc. students for two years each to act as assistants, and equipment and materials required by the topic. Grants given to Thika and NAL will cover the cost of one researcher and one assistant full-time as well as equipment and materials. Research at Thika and NAL is expected to be similar except that the former will concentrate on maize and beans while the latter will concentrate on sorghum, millet, and peas. As maize and beans are more important in the national food supply, two grants are proposed for Thika and only one for NAL. The topics, departments or institutions, and numbers of researchers, graduate students, and assistants involved are as follows:

Long-term research topic	Department/ Institution	Number of researchers/ M.Sc. students/ assistants
(1) Rearing of parasitoids and pathogens for use in control of storage pests.	Zoology-Entomology	1/2/0
(2) The de-toxification of grain infested with aflatoxin	Food Technology	1/2/0
(3) Varietal resistance to attack by common postharvest pests	Crop Science-Agronomy	1/2/0
(4) Grain losses between physiological maturity and storage: maize and beans	Thika	1/0/1
(5) Drying and storage in cribs of varying configuration: maize and beans. (Researcher will want follow up related work being done at FTCs).	Thika	1/0/1
(6) Research on sorghum, millet, and peas. Grain losses between physiological maturity and storage. Drying and storage in cribs of varying configuration.	NAL	1/0/1

2. Requirements and Constraints

The study team believes that it has identified those areas where research is most needed at this time in Kenya. The topics have emerged after a survey of 200 smallholder farmers, discussions with many Kenyan agencies (including those capable of conducting research) and a thorough literature review. It is therefore recommended that USAID restrict the use of the proposed grants, both M.Sc. and long-term, to the undertaking of research on the topics as indicated. The team also believes that Kenyans occupying permanent positions can and should do the research.

Funds provided under this component will be administered by the University of Nairobi, by the National Agricultural Laboratories, and by the National Horticultural Research Station. It is anticipated that the University will utilize an existing framework to award the M.Sc. grants on a competitive basis to students.

The areas of research contained in this component have been provisionally and verbally accepted by the Director of Research, MOA. Participating institutions have also been consulted. However, personnel at these institutions who are to supervise the M.Sc. research or conduct the long-term research should have a chance to review and comment on the research plan.

3. Elements and Costs

The section summarizes the material found in Table VI-19 covering project elements and costs for the research component.

a. M.Sc. Thesis Research Grants

Over the five year life of the project, USAID is expected to grant-fund 10 M.Sc. research projects for Masters students at the University of Nairobi. Cost to USAID is estimated at $14.7 thousand in project year two, peaking at $58.9 thousand in year four, and falling to $ 29.4 thousand in five. Total life of project cost to USAID is estimated at $ 147.2 thousand. Cost to GOK is estimated at Nil. This may be an optimistic expectation as a portion of a professor's salary may have to be paid or a new GOK position added in order to supervise these student projects.

Long-term Research Grants

Over the five-year life of the project, USAID is expected to grant-fund 3 long-term research grants to the University of Nairobi, 2 to the National Horticultural Research Station (Thika), and one to the National Agricultural Laboratories. Research grants cover the salaries and personnel support costs for six senior researchers and three assistants for 4 and one-half years, 6 more M.Sc. students for two years each, and equipment and materials to support research. Cost to USAID is estimated at $ 112.8 thousand in year one and $ 163.0 thousand in each year thereafter. Total life of project cost to USAID is estimated at $ 764.8 thousand. Cost to GOK is estimated at nil.

Total Life of Project Estimated Cost for Research Component

Total life of project costs for the research component are shown by year in Table VI-20. Cost to GOK is estimated at nil. Cost to USAID is estimated at $ 912.0 thousand in 1980 prices or $ 1454.9 thousand in current prices.

Table VI-20. Project component estimated costs: Research (1980 prices)

	Project Year 1		2		3		4		5		Estimated 5-year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
A. 10 M.Sc. Thesis Research Grants												
KENYAN PERSONNEL												
1. Nil	---	---	---	---	---	---	---	---	---	---	---	---
TRAINING												
2. 10 M.Sc.'s at University	---	---	---	14.7	---	44.2	---	58.9	---	29.4	---	147.2
Subtotals	---	---	---	14.7	---	44.2	---	58.9	---	29.4	---	147.2
B. Long-term Research Grants to University, Thika, and NAL												
KENYAN PERSONNEL												
3. 6 senior researchers and 3 assistants	---	42.1	---	84.2	---	84.2	---	84.2	---	84.2	---	378.9
4. Personnel support costs	---	23.2	---	46.3	---	46.3	---	46.3	---	46.3	---	208.4
TRAINING												
5. 6 M.Sc.'s at University	---	---	---	22.1	---	22.1	---	22.1	---	22.1	---	88.4
COMMODITIES												
6. Equipment and materials to support research	---	47.5	---	10.4	---	10.4	---	10.4	---	10.4	---	89.1
Subtotals	---	112.8	---	163.0	---	163.0	---	163.0	---	163.0	---	764.8
GRAND TOTALS	---	112.8	---	177.7	---	207.2	---	221.9	---	192.4	---	912.0
Estimated costs in current prices at 15% inflation per year		129.7		235.0		315.3		388.1		387.0		1,454.9

Notes to Table VI-20

1. GOK contribution includes salaries of professors who supervise M.Sc. students. This is not included as a project cost because no new positions are created under this component.

2. Training for 10 Kenyan M.Sc. students at University of Nairobi. Cost per student is KSh 44,000 per year plus research materials at KSh 9,000 per year. Assume 2 students start in year two, 4 in year three, and 4 in year four.

Project year	1	2	3	4	5
Student years	0	2	6	8	4

3. Salary grant for 6 senior researchers at assistant professor level (KSh 80,000 per year) and 3 assistants at level of senior research fellow (KSh 42,000 per year). All personnel on line from midway through project year one to project year five. While positions may not be new, salaries will be part of the 6 grants.

4. Personnel support costs estimated at 55 percent of salaries.

5. Training for 6 Kenyan M.Sc. students, 3 starting in year two and 3 in year four. Cost per student is KSh 44,000 per year plus research materials at KSh 9,000 per year.

6. Six sets of equipment to support long-term research at University of Nairobi, Thika, and NAL.

Topic	Initial cost	Annual cost
(1) Parasitoids and pathogens	$ 4,000	$1,200
(2) Aflatoxin	6,000	1,500
(3) Varietal resistance	7,500	1,700
(4) Maize and beans prestorage losses	10,000	2,000
(5) Maize and beans storage cribs	10,000	2,000
(6) NAL	10,000	2,000

Project Component J:
Assistance to Agricultural Information Center

1. Project Description

The proposed project resulting from the Kenya National Crop Storage Survey concentrates on education, training, and applied research to increase the capabilities of educational institutions and governmental agricultural service agencies. These efforts are directed towards areas of particular importance to post harvest and storage technology in order for information and techniques to be disseminated and adapted by smallholder farmers.

A major source for the development and dissemination of materials and ideas of recommended farming technology has traditionally been an Agricultural Information Agency, which is usually a part of the agricultural educational services of a country. Kenya's strategy is similar in this respect. The Ministry of Agriculture includes an Agricultural Information Center (AIC). The facilities are new. The staff is enthusiastic to be able to assist in developing an additional capacity of communications media that will be useful in the area of postharvest technology.

With the cooperation of AIC, the Postharvest and Storage Section, Farmer Training Centers, Embu and Bukura Institutes of Agriculture, Home Economics Extension, organizations of applied research included in this proposed project and any other MOA Division or Branch would benefit greatly from the production and dissemination of written and visual materials through AIC communications media. The informational ideas would originate with the professional staff of the various above-listed subunits of MOA and would be produced in liaison with AIC staff. To augment AIC's budget, and provide needed project impetus during the initial five years of the project for the costs of materials, printing and special services (e.g. movie film processing and print reproductions), it is proposed that USAID funds be allocated for these purposes. This output by AIC will be most necessary and useful in conducting the educational and training activities of instructors, extension workers and smallholder farmers. The funds would be administered through the Project's Administrative and Coordinating Officer - the Chief of Party, in cooperation with AIC, after the proposed work, identified with the above MOA institutions and agencies, was mutually agreed upon.

Specific assistance, in the form of commodities and services that are recommended for AIC use, is listed as follows:

- The printing costs of publications - bulletins, leaflets, circulars, and similar informational materials

- The printing costs of posters and one page illustrated messages

- The costs of tapes to be used for radio programs and narrations to illustrated or slide presentations

- Film, development and duplication costs of slide sets

- Movie film and duplication of film costs

- Film, processing, and duplication costs for photography needs

2. Requirements and Constraints

To provide mass communications services to a postharvest loss prevention program, MOA/AIC will be obligated to allocate staff time and reproduction facilities of AIC to the production of written, visual and verbal (radio) information and materials. The extent of production will depend upon the annual budget as provided by USAID and administered by the Project Chief of Party for specified commodities and services and by GOK for the ongoing salaries of personnel on duty and their travel costs as required to perform the postharvest loss prevention duties.

The National Radio, Voice of Kenya, presently devotes three hours per week to agricultural information. This is much less than could be justified considering the economic importance of agriculture in Kenya. Careful consideration should be given to the timing of agricultural programs. This Survey found that evening is the prime time for reaching farmers, the exact hours for scheduling should be determined from a more extensive study. Some programs might be repeated during morning and noon hours.

3. Elements and Costs

This section summarizes the material presented on Table VI-21 covering project commodities and services for assistance to the Agriculture Information Center.

a. Commodities and Services

During the five years of the project, GOK and USAID are expected to share costs for the AIC overall contribution to the project. GOK will continue to pay the personnel salaries and associated costs, their travel expenses when making films, photos, etc., and provide the facilities and equipment already in use at AIC headquarters. USAID will provide funds for the commodities and services as previously outlined and further explained in the reference notes to Table VI-21.

b. Total Life of Project Estimated Costs for Agriculture Information Center Component

Life of the Project Costs for the AIC component are presented year by year in Table VI-21. Total USAID costs for this component are estimated at $266.0 thousand in current prices. There are no additional GOK costs included because there would be no additional personnel required and existing headquarters facilities and equipment would be used.

Table VI-21. Project component estimated costs: Assistance to AIC (1980 prices)

	Project Year 1		2		3		4		5		Estimated 5-year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
COMMODITIES AND SERVICES												
1. Movie films and prints	---	14.0	---	28.0	---	28.0	---	28.0	---	21.0	---	119.0
2. Slide sets												
a. Production	---	0.2	---	0.4	---	0.4	---	0.4	---	0.2	---	1.6
b. Duplication	---	2.0	---	4.0	---	4.0	---	4.0	---	2.0	---	16.0
3. Posters	---	2.0	---	8.0	---	8.0	---	8.0	---	4.0	---	30.0
4. Publications	---	5.0	---	10.0	---	20.0	---	20.0	---	15.0	---	70.0
5. Photography	---	0.3	---	0.6	---	0.6	---	0.6	---	0.3	---	2.4
6. Tapes	---	2.0	---	4.0	---	8.0	---	8.0	---	5.0	---	27.0
GRAND TOTALS	---	25.5	---	55.0	---	69.0	---	69.0	---	47.5	---	266.0
Estimated foreign exchange component costs in $US (1,000)	---		---		---		---		---		---	
Estimated costs in current prices at 15% inflation per year		29.3		72.7		104.9		120.7		95.5		423.2

Reference Notes

1. Costs are estimated at the rate of $7,000 per 10 minute movie with approximately 20 prints.
2. For $200 about five sets of 36 slides can be produced. For $2,000 approximately 60 sets can be reproduced.
3. The costs of posters are variable depending on size and quality of paper. Due to their purported popularity and effectiveness, the estimated annual budgets listed are recommended.
4. The costs of publication and distribution of bulletins, pamphlets, circulars and leaflets are estimated at the amounts indicated on annual basis.
5. Film and processing costs are estimated at this rate of expenditure.
6. This line item is for tapes to be used mainly for radio programs, at the rate of estimated expenditure listed.

Project Component K:
Assistance to the Home Economics and Youth Branch, MOA

1. Project Description

By tradition the smallholder farm wives or female heads of households, perform several of the major tasks in the storage of food grains and pulses. They provide their share of labor during harvesting; they assist in gathering materials for the construction of storage cribs; they are in charge of maintaining the quality of grain in storage; and they are responsible for removing grain from storage for shelling, sorting, grinding or otherwise preparing it for family consumption. This means that the Kenyan smallholder farm women are important contributors when it comes to reducing on-farm postharvest food grain losses. This fact is further emphasized and supported by data obtained from the smallholder questionnaires administered during the field survey and reported in Chapter IV.

The women's component of the total project includes several educational and training opportunities. Women will always be urged to attend one-week courses in postharvest and storage technology at FTCs. However, in the past, few women have attended owing to conflicting family responsibilities. To encourage more attendance, some FTCs are beginning to provide lodging facilities which will accomodate mothers with children. Also, this project has provided for field training courses (in section B.1.c. above) in post-harvest and storage technology aimed at groups, particularly women, who do not normally attend residential training courses at FTCs. This training will take place at community centers, schools, churches, etc., throughout Kenya and at no charge to those who attend. It is anticipated that women will take advantage of this opportunity to participate in courses offered near their homes.

In addition, after consultations with MOA personnel, it is recommended that the present project component provide for M.Sc. training abroad for one Kenya degree (or diploma) holder in the Home Economics Branch, MOA. Specifically, it is recommended that this individual obtain an M.Sc. degree in Home Economics during project years two and three with a major in nutrition and a minor in extension. There are two possible locations for the overseas training which might logically be considered. The first would be at the University of the Phillipines in Los Banos where an excellent M.Sc. program in nutrition exists and where there is long history of training women in agricultural extension. This program may be more relevant than a U.S. program. If a U.S. program were selected, Kansas State University might be a logical location so the student could take advantage of the summer short course in grain storage.

Upon returning to Kenya, this M.Sc. holder will be posted at headquarters and provide leadership in extension activities related to nutrition and grain storage. This work will involve a liaison with the Post-Harvest and

Storage Section, the Agricultural Information Center, Embu and Bukura Institutes of Agriculture, Farmer Training Centers and extension home economists. The ultimate objective is to provide appropriate institutional backstopping in order to reach more farm women with relevant information pertaining to the postharvest handling of food grains.

2. Requirements and Constraints

This project component will be administered by MOA who will release one Kenyan degree (diploma) holder from the Home Economics and Youth Branch for M.Sc. training abroad during project years two and three. MOA will also continue to pay 80 percent of this individual's salary while abroad. No new position will be created within the Home Economics and Youth Branch under this component.

3. Elements and Costs

This section summarizes the material found on Table VI-22 covering project elements and costs for assistance to the Home Economics Branch of MOA.

Salaries for Kenyan personnel are not included as a project cost because no new positions will be created within GOK under this project component. The cost of M.Sc. training for one Kenyan will be shared by GOK and USAID. GOK will pay one-way airfare for a total cost of KSh 9.4 thousand in year two. USAID will pay all other costs which come to $25.0 thousand in year two and $26.3 thousand in year three. These are costs in constant 1980 prices. Total life of project costs in current prices are KSh 12.4 thousand to GOK and $US 73.1 thousand to USAID.

Project Component L: Assistance to the Land Development Division, MOA

1. Project Description

The Land Development Division is the section in the Ministry of Agriculture that provides technical services to the Ministry in Engineering matters. This includes the areas of soil and water conservation, irrigation services, farm machinery, farm building design and construction, i.e. livestock sheds, workshops, etc., and crop storage structures.

At present, the division is involved in a modest campaign of introducing improved crop storage structures and facilities such as cement jars, concrete silos, maize cribs, and potato stores. The division's most visible activity in disseminating improved storage facilities is the display of prototype models in showgrounds of the country. While this approach of reaching the intended clientele is commendable, its effectiveness in convincing Kenyan farmers to adopt an innovation is quite limited. This can be attributed to the fact that only a small segment of the farmers ever go to the showgrounds

Table VI-22. Project component estimated cost: Assistance to Home Economics and Youth Branch (1980 prices)

	Project Year 1		2		3		4		5		Estimated 5 year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
KENYAN PERSONNEL												
1. Nil	---	---	---	---	---	---	---	---	---	---	---	---
TRAINING												
2. One M.Sc. to Phillipines or USA	---	---	9.4	25.0	---	26.3	---	---	---	---	9.4	51.3
GRAND TOTALS	---	---	9.4	25.0	---	26.3	---	---	---	---	9.4	51.3
Estimated costs in current prices at 15% infiation per year	---	---	12.4	33.1	---	40.0	---	---	---	---	12.4	73.1

Reference Notes

1. GOK contribution includes salary of trainee while abroad but this is not included as a project cost because no new positions are created under this component.

2. All-inclusive cost of $25,000 per year each year in USA (equal cost assumed for Phillipines). One-way air-fare of $1,300 paid by GOK. Return fare paid by USAID.

and fewer still will be convinced to adopt an innovation unless the prototype being displayed is actually being used and proven superior to their existing methods of storage.

It appears that the efforts directed towards the introduction of improved crop storage techniques to small farm holders can be enhanced if the division develops its capability in:

- providing active technical backstopping to the postharvest section of MOA, i.e. design and construction of improved crop storage facilities

- expanding its present activities in displaying improved crop storage facilities at show grounds, i.e. by actually using such storage prototypes

- Providing appropriate designs to the Agricultural Information Center for dissemination to farmers in the form of leaflets, pamphlets, etc., and

- supervising the construction of demonstration drying platforms and maize cribs at FTCs.

It is therefore, recommended that the farm structures branch be expanded within the division. To augment its existing capability the division should have at least initially an agricultural engineer to be sent abroad for an M.Sc. degree at Iowa State University, U.S.A. A second agricultural engineer will be trained locally in grain drying and storage a year after the former leaves for overseas training. The second engineer will be sent to obtain an M.Sc. degree at the Agricultural Engineering Department University of Nairobi. This engineer can avail himself or herself of the research grant provided by in the research component of this project to support his or her graduate research program in the University.

2. Requirements and Constraints

This project component will be administered by MOA which will create two positions in the Land Development Division, recruit two Kenyan Agricultural Engineers to fill the positions and then release them for advanced training (M.Sc. degree) overseas and locally. It is preferred that a farm structures engineer be appointed at the middle of year one about a year prior to his departure for the US. Similarly, the second engineer may be appointed during early part of year two at least six months prior to going for an advanced degree locally. The MOA will continue to pay 80 percent of the salary of both engineers while undergoing advanced degree work.

Also, it is assumed that the Land Development Division will provide office space for the engineers; office and the drafting equipment will be provided by USAID under the program.

3. Elements and Costs

This section summarizes the material found in Table IV-23 covering project elements and costs for assistance to the Land Development Division of the Ministry of Agriculture.

a. Commodities

USAID and GOK will share the cost of the commodities. USAID being responsible for the initial cost and GOK for operating, repairing, and maintaining them. Cost to USAID is estimated at $ 2.5 thousand in year two and $ 1.5 thousand in year three and a total of $ 4.0 thousand for the entire life of the project. Cost to GOK is estimated at KSh 6.0 thousand in year two, KSh 0.5 thousand each in years three, four and five. Total GOK life of the project costs for commodities are estimated at KSh 7.5 thousand. Table VI-24 lists the equipment that will be provided.

b. Total Cost for Land Development Division of MOA Component

Life of Project costs for the Land Development Division of MOA component are shown by year in Table VI-23. Total USAID costs for this component are estimated at $ 67.5 thousand in 1980 prices or $ 98.7 thousand in current prices. Of the former, $ 63.5 thousand is for the training component. Total GOK costs are estimated at KSh 351.80 thousand in 1980 prices at KSh 576.3 thousand in current prices. No GOK foreign exchange is estimated as the drafting equipment brought into the country should need very minimal maintenance and repair.

Project Component M: Technical Services to the Contract

1. Project Description

The previous 12 components of the project have been described in detail in sections A to L of this chapter. In all, the project is supporting 8 departments within MOA in addition to 4 other GOK institutions. Some departments/institutions are involved in research on postharvest handling and storage practices, others provide institutional backstopping for the agricultural extension service, others train extension others train farmers in the application of improved postharvest practices. All have their role to play in achieving the ultimate objective.

The type of support given by the project to these departments/institutions falls into five categories: salaries and support for Kenyan personnel, training of Kenyan personnel, commodities, farmer training, and expatriate technical assistance. The project in its five years provides for the salaries and support of the following Kenyan personnel, Table VI-25.

Table VI-23. Project component estimated cost: MOA Land Development Division (1980 prices)

	Project Year 1		2		3		4		5		Estimated 5-year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
KENYAN PERSONNEL (Salaries)												
1. Farm structures Engineer	15.0	---	24.0	---	24.0	---	30.0	---	30.0	---	123.0	---
2. Crop processing Engineer	---	---	15.0	---	24.0	---	24.0	---	30.0	---	93.0	---
3. All personnel support for Kenyan Officers	8.2	---	21.5	---	26.4	---	29.7	---	33.0	---	118.8	---
Subtotals	23.2	---	60.5	---	74.4	---	83.7	---	93.0	---	334.8	---
TRAINING PROGRAMS												
4. 2-M.Sc. degree for Kenyans												
1 Overseas	---	---	9.4	25.0	---	26.3	---	---	---	---	9.4	51.3
1 Local	---	---	---	---	---	6.1	---	6.1	---	---	---	12.2
Subtotals	---	---	9.4	25.0	---	32.4	---	6.1	---	---	9.4	63.5
COMMODITIES												
5. Drafting equipment	---	---	---	2.0	---	1.0	---	---	---	---	---	3.0
6. Technical books	---	---	---	0.5	---	0.5	---	---	---	---	---	1.0
7. Drafting tables	---	---	4.0	---	---	---	---	---	---	---	4.0	---
8. Office desks and supp.	---	---	2.0	---	0.5	---	0.5	---	0.5	---	3.5	---
Subtotals	---	---	6.0	2.5	0.5	1.5	0.5	---	0.5	---	7.5	4.0
GRAND TOTALS	23.3	---	75.9	27.5	74.9	33.9	84.2	6.1	93.5	---	351.8	67.5
Estimated Foreign Exchange Component for GOK cost in $US(1,000)	---	---	---	---	---	---	---	---	---	---	---	---
Estimated costs in current prices at 15% inflation per year	26.7	---	100.3	36.4	113.9	51.6	147.3	10.7	188.1	---	576.3	98.7

Reference Notes

1. Farm structures engineer hired at full salary for one-half of year one, then paid 80 percent while in training. Two-year training period, return beginning year four. Starting salary: KSh 30,000 (1980/81 level).
2. Crop processing engineer hired at full salary for one-half of year two, then paid 80 percent while in training. Two-year training period, return beginning year five. Starting salary: KSh 30,000 (1980/81 level).
3. Estimated at 55 percent of personnel salaries, and include housing allowances, uniforms, and travel and accomodation while on duty in country.
4. Two years in USA at $25,000 per year (1980 cost). Air fare at $2,600 return of which GOK pays one-half.
5. KSh 44,000 per year at University of Nairobi (1980 basis).
6. One drafting machine supplied in each of years two and three. Other drafting equipment supplied year two. See Table IV-24.
7. $500 of technical books supplied in each of years two and three.
8. Manufactured locally. Estimated at KSh 4,000.
9. Initial cost of KSh 2,000 and KSh 1,000 thereafter.

Table VI-24. List of equipment for the Land Development Division of the Ministry of Agriculture

	Item description (size/capacity)	Total required	Estimated unit cost	Estimated total cost
			----------$US----------	
	DRAFTING EQUIPMENT			
1.	Drafting machine	2 units	1,000	4,000
2.	Drafting instruments; compass, dividers, inking pens, etc. triangles 30° x 60° and 45° x 45°	2 sets	200	400
3.	Drafting pens	2 sets	100	200
4.	Templates for lettering	2 sets	150	300
5.	Templates for symbols	2 sets	50	100
				3,000
	TECHNICAL BOOKS			
6.	Engineering handbooks for farm structures and crop processing		1,000	1,000
	Grand Total			4,000

Table VI-25. Summary of Kenyan nationals who will be involved in the project

Position	Person years in each project year				
	1	2	3	4	5
Degree - administrator	2	3	3	6	9
Degree or diploma	1	6.5	7	7	7
Diploma	-	-	-	3	6
Certificate	-	11	11	11	11
Drivers	1.5	3	3	6	9
Senior researcher	3	6	6	6	6
Assistant	1.5	3	3	3	3
Total	9	32.5	33	42	51

The project also provides for training of Kenyan personnel, as follows:

Type of training	Training beginning or taking place in project year				
	1	2	3	4	5
M.Sc. in USA	-	4	-	-	-
M.Sc. at U. of Nairobi	-	5	7	9	-
Short course at K. State	2	-	-	-	-
Short course at TPI	-	2	2	6	6
One-week courses	-	800	800	-	-

The project will provide commodities to departments/institutions as follows:

1. Post-Harvest and Storage Section, MOA stored products protection laboratory; 9 vehicles.

2. Farmer Training Centers; 23 sets of demonstration cribs and drying platforms, grain quality monitoring equipment, and teaching aids.

3. Smallholder farmers: 9800 demonstration cribs and drying platforms.

4. Egerton College: insectary screen and rearing rooms; equipment for crop processing laboratory.

5. Embu/Bukura: 2 sets of grain quality monitoring equipment and teaching aids.

6. University of Nairobi: research materials for 10 M.Sc. grants and 3 long-term grants; moisture determination equipment, scales and balances, grain quality testing equipment, air property measuring equipment, temperature measuring equipment, all for the Agricultural Engineering department.

7. Central Bureau of Statistics: 150 sets of moisture meters, chemicals for killing insects, plastic bags and labels in each of years two and five.

8. National Horticultural Research Station (Thika): reserach materials for 2 long-term grants.

9. National Agricultural Laboratories (Kabete): research materials for 1 long-term grant.

10. Agricultural Information Center: films; slide sets; posters; publications; radio tapes.

11. Land Development Division, MOA: drafting equipment; technical books and manuals.

In its five years, the project will train smallholder farmers in postharvest and storage technology, as follows:

Type of course	Number of farmers in each project year					
	1	2	3	4	5	Total
Residential training at FTCs	-	2800	7400	9200	9200	28,600
Field training	-	1400	3700	4600	4600	14,300
Total	-	4200	11,100	13,800	13,800	42,900

Finally, the project will provide expatriate technical assistance to the following departments/institutions:

Department/institution	Person years in each project year				
	1	2	3	4	5
Post-Harvest and Storage Section, MOA	1	3	3	2	-
Embu/Bukura	.5	1	.5	-	-
U. of Nairobi, agricultural engineering department	.5	1	1	.5	-
Total	2	5	4.5	2.5	-

In sum, the project is comprehensive, covering all aspects of postharvest handling and storage of grains on smallholder farms in Kenya. There is a need to coordinate USAID assistance of the various forms to the departments and institutions involved.

The USAID mission has a number of policies in this regard. First, the project contract should be awarded to a contractor on a competitive bid basis. Then, in order to economize on the use of direct-hire personnel, a minimum of USAID funds should be administered directly by the USAID mission and a maximum by the contractor. Secondly, the contract should be a host country contract under a lead Ministry. In this case, the lead Ministry should obviously be the Ministry of Agriculture who would then be responsible for establishing some mechanism to coordinate project activities with the other institutions involved.

a. Chief of Party

As a result of the above policies, and in view of the need to coordinate the diverse project activities, the consultants recommend that the project provide for one expatriate to act as Chief of Party for the entire five years of the project. He should further be provided with two Kenyan administrative assistants, an official vehicle, office equipment and office supplies. It is assumed that he will be able to work out of his home as an office.

The responsibilities of this expatriate should be as follows:

1. to act on behalf of the contractor for services which the contractor is required to provide in Kenya. This includes the construction of the PHSS laboratory which the contractor will have the responsibility of building

2. to order commodities supplied under the project and consign them to the various institutions for which they are destined, (it should be the responsibility of GOK to clear the commodities arriving from overseas through customs).

3. to confirm the delivery of commodities to the various institutions,

4. to confirm the construction of demonstration cribs and drying platforms at FTCs and at cooperating small farm holders,

5. to confirm that the Central Bureau of Statistics is collecting samples of maize and beans from smallholders, that these are being forwarded to and analyzed by the PHSS laboratory, and the results of the analysis are being returned to CBS,

6. to participate in the selection process of Kenyan trainees, to confirm that they have been selected and that they are undergoing the designated training,

7. to confirm that MOA in-service training courses are being held at five designated regional FTCs,

8. to assist the other expatriates in establishing themselves in Kenya (This includes locating houses and handling shipments of personal effects),

9. generally to administer funds provided under the project by USAID and allocated to the contractor to administer, and

10. to write periodic reports (every six months) to USAID and GOK on the progress of the project and to write special reports as the need arises.

b. Short-term Consultants

It is never the case that a project is implemented without unforeseen problems. Owing to the complexity of postharvest handling and storage technology, several components of the project deal with highly technical subject matter on which personnel involved in the project may not be able to get adequate advice in country. Examples include the following:

- research activities at the University of Nairobi, especially the problems of detoxifying aflatoxin-infested grain; there could be a need for a biochemist to assist University researchers;

- research activities at Thika and NAL,

- development of mass communications in the Home Economics and Youth Branch of MOA,

- production of films, slide sets, posters, publications, and radio tapes at the Agricultural Information Center.

In case of such contingencies, the consultants recommend that the project provide for expatriate short-term consultants for a total of 12 person-months to provide technical expertise to personnel involved in the project. At this writing, it is not possible to specify precisely what the duties of the short-term consultants would be. The above list should be considered

illustrative not exhaustive. Rather, the project will simply provide for four person-months of short-term consultants in each of project years two, three, and four.

2. Requirements and Constraints

All costs incurred under this component are entirely the responsibility of USAID. However, acceptance of this component by GOK along with all its implications is an integral part of the agreement by USAID and GOK jointly to fund and implement the project. If only for auditing purposes, USAID requires the assurance that funds provided under the project are used for the designated purposes. This assurance can best be provided, within the constraints set by USAID Mission policies, in the form of an expatriate Chief of Party aided by two Kenyan administrative assistants.

3. Elements and Costs

This section summarizes the material found in Table VI-26 covering elements and costs of the technical services component.

Kenyan Personnel

Cost of two administrative assistants is expected to be borne entirely by USAID at $ 10.3 thousand per year for a total life of project cost of $51.5 thousand.

Commodities

USAID is expected to bear the entire costs of commodities including one official vehicle for the expatriate, office equipment, and office supplies. Cost to USAID is estimated to be $ 25.6 thousand in year one and $ 6.7 thousand in each year thereafter, for a total life of project cost of $56.4 thousand.

Expatriate Technical Assistance

USAID is expected to bear the entire costs of the Chief of Party and the 12 person-months of short-term consultants. Life of project cost is estimated at $ 900.0 thousand.

Total Life of Project Costs for Technical Services Component

Total life of project costs for the technical services component are shown year by year in Table VI-26. Total life of project cost to USAID is estimated at $ 1003.9 thousand in 1980 prices or $1546.5 thousand in current prices. Total life of project cost to GOK is estimated at nil.

Table VI-26 Project component estimated costs: Technical services (1980 prices)

	Project Year 1		2		3		4		5		Estimated 5-year totals	
	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)	GOK (KSh)	USAID ($US)
	(1,000)											
KENYAN PERSONNEL												
1. Admin. Assistants	---	10.3	---	10.3	---	10.3	---	10.3	---	10.3	---	51.5
Subtotals	---	10.3	---	10.3	---	10.3	---	10.3	---	10.3	---	51.5
COMMODITIES												
2. Vehicle	---	10.0	---	---	---	---	---	---	---	---	---	10.0
3. O.R.M.	---	1.6	---	2.7	---	2.7	---	2.7	---	2.7	---	12.4
4. Office equipment	---	10.0	---	---	---	---	---	---	---	---	---	10.0
5. O.R.M.	---	1.0	---	1.0	---	1.0	---	1.0	---	1.0	---	5.0
6. Office supplies	---	3.0	---	3.0	---	3.0	---	3.0	---	3.0	---	15.0
Subtotals	---	25.6	---	6.7	---	6.7	---	6.7	---	6.7	---	56.4
EXPATRIATE TECHNICAL ASSISTANCE												
7. One Chief of Party	---	150.0	---	150.0	---	150.0	---	150.0	---	150.0	---	750.0
8. Short-term consultants	---	---	---	50.0	---	50.0	---	50.0	---	---	---	150.0
Subtotals	---	150.0	---	200.0	---	200.0	---	200.0	---	150.0	---	900.0
GRAND TOTALS	---	185.9	---	217.0	---	217.0	---	217.0	---	167.0	---	1,003.9
Estimated costs in current prices at 15% inflation per year	---	213.8	---	287.0	---	330.3	---	379.5	---	335.9	---	1,546.5

Reference Notes

1. Two administrative assistants for entire five years at diploma level: KSh 24,000 per year plus 55 percent for personnel support.
2. One 2 WD sedan at $10,000 supplied in year one.
3. Gas, oil, and tires at 10 cents per mile. Average of 12,000 miles per year. Maintenance at 3.75 percent of initial cost in year one and 15 percent thereafter.
4. Initial cost at $10 000 supplied in year one.
5. Estimated at 10 percent of initial cost in each year.
6. Estimated at $3,000 in each project year.
7. Chief of Party throughout project. One expat at $150,000 per year for all costs: Salary; benefits; transport of family, household goods, personal effects and vehicles; education, post, hardship allowance; housing, per diems; etc.
8. Four person-months of short-term expatriate consultants in each of years two, three, and four. Estimate of $50,000 per year for all costs: Salary; benefits; international air travel; travel and accomodation in Kenya; etc.

N. Summary

The total cost for the components of this project in 1980 prices is KSh 6,740,900 plus $ 6,529,900 as shown in Table VI-27. The total cost if a 15 percent inflation rate is applied to prices is KSh 11,388,100 plus $10,189,600 as shown in Table VI-28.

Translated to dollars the Kenyan contribution is $ 936,236 or 14.34 percent of the total costs as shown. If a larger component of Kenyan contribution is desired it could come by shifting $ 498,000 of the USAID contribution to the cost of training farmers at FTCs and in the field. This shift would provide a Kenyan contribution of about 24 percent of total costs.

It should be noted that there is a large Kenyan contribution of existing personnel time and office space which has not yet been credited to GOK costs. Also, the cost of land for the PHSS laboratory has not been credited.

Of the total costs as calculated, there is a possibility that USAID costs of $1,014,300 in 1980 prices or $ 1,722,100 in current prices could come from SPSCP reflow funds, covering the costs of training farmers and extending partial grants for cribs and drying platforms in Western and Nyanza Provinces. Similarly, GOK costs of KSh 460,600 in 1980 prices or KSh 782,000 in current prices could come from SPSCP reflow funds.

Of the total USAID costs, approximately $ 317,300 in 1980 prices or $ 378,700 in current prices could represent a loan to GOK. This covers the cost of constructing the PHSS laboratory and four houses for expatriates.

REFERENCES

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(5) Smith, L.D. and Coordinating Committee of the Project. Summary of Major Technical Studies and Recommendations for Agricultural Marketing Development, (KEN/75/005). FAO, Marketing Development Project Phase I, Nairobi, 1978.

(6) Lindblad, C and Druben, J. Small farm grain storage. Action/Peace Corps. Washington, D.C., 1976.

Table VI-27. Summary of project costs, 1980 prices

	Reference Table	Project Year 1 GOK (KSh)	1 USAID ($US)	2 GOK (KSh)	2 USAID ($US)	3 GOK (KSh)	3 USAID ($US)	4 GOK (KSh)	4 USAID ($US)	5 GOK (KSh)	5 USAID ($US)	Total, 5 years GOK (KSh)	Total, 5 years USAID ($US)
		(1,000)											
A. Establish Post-Harvest and Storage Section, MOA	VI-1	270.1	337.3	837.8	500.0	812.6	514.8	1,184.3	383.3	1,566.8	71.0	4,671.5	1,806.4
B. Training farmers at FTC's	VI-4	---	19.4	140.6	114.0	372.9	194.1	474.0	160.3	474.0	160.3	1,461.5	648.1
C. Grants to Smallholders	VI-6	---	---	---	120.6	---	241.1	---	241.1	---	241.1	---	843.9
D. Assistance to cooperatives	VI-10	Not recommended for funding at this time											
E. Assistance to Egerton College	VI-12	10.9	30.2	24.3	2.0	24.3	2.0	24.3	2.0	24.3	2.0	108.1	38.2
F. Assistance to Embu and Bukura Institutes	VI-14	6.4	86.8	27.9	159.6	26.4	84.6	11.4	---	11.4	---	83.5	331.0
G. Assistance to University of Nairobi	VI-16	1.4	86.1	6.9	161.1	10.9	150.0	9.4	75.0	8.0	---	36.6	472.2
H. Assistance to Central Bureau of Statistics	VI-18	18.7	10.2	---	43.8	---	---	---	---	---	35.4	18.7	89.4
I. Research	VI-20	---	112.8	---	177.7	---	207.2	---	221.9	---	192.4	---	912.0
J. Assistance to Agricultural Information Service	VI-21	---	25.5	---	55.0	---	69.0	---	69.0	---	47.5	---	266.0
K. Assistance to Home Economics and Youth Branch	VI-22	---	---	9.4	25.0	---	26.3	---	---	---	---	9.4	51.3
L. Assistance to Land Development Division	VI-23	23.2	---	75.8	27.5	74.9	33.9	84.2	6.1	93.5	---	351.6	67.5
M. Technical Services to contact	VI-25	---	185.9	---	217.0	---	217.0	---	217.0	---	167.0	---	1,003.9
TOTAL		330.6	894.2	1,122.7	1,603.3	1,322.0	1,740.0	1,787.6	1,375.7	2,178.0	916.7	6,740.9	6,529.9
(of which funds might come from SPSCP reflow)		---	---	(65.8)	144.9	131.6	289.8	131.6	289.8	131.6	289.8	460.6	1,014.3
(of which possible loan component of USAID costs)		---	237.3	---	80.0	---	---	---	---	---	---	---	317.3

Table VI-28. Summary of project cost, current prices at 15 percent inflation per year

	Reference Table	Project Year 1 GOK (KSh)	1 USAID ($US)	2 GOK (KSh)	2 USAID ($US)	3 GOK (KSh)	3 USAID ($US)	4 GOK (KSh)	4 USAID ($US)	5 GOK (KSh)	5 USAID ($US)	Total, 5 years GOK (KSh)	Total, 5 years USAID ($US)
		(1,000)											
A. Establish Post-Harvest & Storage Section, MOA	VI-1	310.5	387.9	1,108.0	661.2	1,235.9	782.9	2,071.3	670.4	3,151.4	287.2	7,877.1	2,789.6
B. Training farmers at FTC's	VI-4	---	22.3	185.9	150.8	567.1	295.2	829.0	280.4	953.4	322.4	2,535.5	1,071.1
C. Grants to Smallholders	VI-6	---	---	---	159.5	---	366.7	---	421.7	---	484.9	---	1,432.8
D. Assistance to Cooperatives	VI-10	Not recommended for funding at this time											
E. Assistance to Egerton College	VI-12	12.5	34.7	32.1	2.6	37.0	3.0	42.5	3.5	48.9	4.0	173.0	47.8
F. Assistanct to Embu and Bukura Institutes	VI-14	7.4	99.8	36.9	211.1	40.2	128.7	19.9	---	22.9	---	127.3	439.6
G. Assistance to University of Nairobi	VI-16	1.6	99.0	14.4	213.1	16.6	228.1	16.4	131.2	16.1	---	65.1	671.4
H. Assistance to Central Bureau of Statistics	VI-18	21.5	11.7	---	57.9	---	---	---	---	---	71.2	21.5	140.8
I. Research	VI-20	---	129.7	---	235.0	---	315.3	---	388.1	---	387.0	---	1,454.9
J. Assistance to Agricultural Information Centre	VI-21	---	29.3	---	72.7	---	104.9	---	120.7	---	95.5	---	423.2
K. Assistance to Home Economics and Rural Youth Branch	VI-22	---	---	12.4	33.1	---	40.0	---	---	---	---	12.4	73.1
L. Assistance to Land Development Division	VI-23	26.7	---	100.3	36.4	113.9	51.6	147.3	10.7	188.1	---	576.3	98.7
M. Technical services to contract	VI-25	---	213.8	---	287.0	---	330.3	---	379.5	---	335.9	---	1,546.5
TOTAL		380.2	1,028.2	1,490.0	2,120.4	2,010.7	2,646.7	3,126.4	2,406.2	4,380.8	1,988.1	11,388.1	10,189.6
(of which funds might come from SPSCP reflow)		---	---	87.0	191.6	200.1	440.7	230.2	506.9	264.7	582.9	782.0	1,722.1
(of which possible loan component of USAID costs)		---	272.9	---	105.8	---	---	---	---	---	---	---	378.7

VII. ECONOMIC ANALYSIS OF THE PROJECT

A. General Approach

The major purpose of this chapter is to show why GOK and USAID should commit scarce budgetary resources as specified in Chapter VI to implement the project. This involves a cost-benefit analysis of the entire project taken as a single package. This introductory section outlines the general approach taken in conducting this analysis, including the length of project period for economic analysis, the estimation of costs, the estimation of benefits, respectively. Section D combines the estimated costs and benefits to derive an internal rate of return to the project. It also performs a sensitivity analysis and discusses the implications of this analysis for the success of the project.

1. Length of Project Period

The life of the project as laid out in Chapter VI is five years. However, owing to the nature of the project, it is unrealistic to think that the project could pay for itself in this period of time. The project in its initial years involves considerable expenditures by both GOK and USAID to train MOA personnel in postharvest and storage technology, to set up institutional backstopping for the extension service, and to conduct research. The effect of these activities in terms of helping the ultimate beneficiaries - the smallholder farmers in Kenya - can only be many years down the road. Therefore it will be necessary to estimate the costs and benefits of the project for more than five years. As an alternative, it has been decided to perform the analysis for a 15-year period starting in project year one. The present value of $1.00 of benefits 15 years in the future discounted at 15 percent is only 12¢. Hence, while it is worthwhile performing the analysis for up to 15 years, it would probably make little difference to the overall results if it were done for more than 15 years. For these very reasons, 15 years is a standard length of project period for analyses of this kind.

2. Estimation of Costs

The major interest in this chapter is to estimate the return which GOK and USAID derive from resources which they commit to the project. Therefore the appropriate costs to include in the cost-benefit analysis are the project costs to GOK and USAID. These have already been estimated, component by component in Chapter VI. USAID costs, of course, terminate at the end of project year five. GOK costs, on the other hand, continue for the entire 15 years, whether these be for Kenyan personnel, training, or commodities. The major part of section B is concerned with estimating GOK costs for 15 years.

From the point of view of GOK, USAID grant assistance is free. Therefore, in deciding whether to implement the project, GOK should be most interested in the rate of return to its own resources committed while USAID should be most interested in the rate of return to all resources committed, both GOK and USAID. Both agencies presumably have a large number of projects from which they can choose to commit funds within a budget constraint. A ranking of projects by means of their respective internal rates of return is one way of making such a decision. Still, there remain two points of view, and in section D below, the internal rates of return are calculated in two ways: (1) to GOK costs alone and (2) to total project costs, both GOK and USAID.

Whether it be zero or positive, the marginal cost of smallholder labor, say, in gathering materials, building cribs, or treating grain with insecticide is not treated as a project cost in the subsequent analysis. In Chapter V, there is a private cost-benefit analysis from the smallholder's point of view which shows that it is profitable for him to adopt the recommended post-harvest practices once he has learned about them. The cost of smallholder labor is rightly included in this latter analysis, but it should not be included in the project level analysis. The essential reason for proposing the present project is that the market is failing to produce and transmit knowledge to smallholder farmers concerning how to handle and store their grain better. Knowledge of this kind is a public good which private economic agents lack the incentive to produce and deliver in socially beneficial amounts. This drives a wedge between private and social costs and benefits which the current project is designed in part to correct by paying the costs of producing and transmitting this knowledge. Therefore the appropriate costs to include in the project level analysis are the marginal costs of producing and transmitting this knowledge, which are precisely the GOK and USAID project costs. These should be weighed against the marginal benefits, as discussed in the following section, in order to calculate the rate of return to the project. The presumption is that once the appropriate knowledge has been produced and transmitted, then smallholder farmers will be induced to change their behavior purely from the prospect of personal gain.

3. Estimation of Benefits

Figure V-1 in Chapter V presents a schematic view of the various types of benefits that are envisaged to flow from the proposed project. The ultimate beneficiaries of the project are seen to be the smallholder farmers of Kenya and the ultimate benefits to be reduced postharvest grain losses on smallholder farms. Conceptually, this is a tangible benefit being so many tons of grain valued at some appropriate price. But in order to reach the smallholder farmers and to achieve such reductions in grain losses, it is first necessary to develop recommended postharvest practices, to set up institutional backstopping for the agricultural extension service, to train extension personnel, and to train farmers. These are all benefits in their own right which flow from project activities to support research, and to assist the Ministry of Agriculture, the University of Nairobi, Egerton College, and Embu/Bukura Institutes of Agriculture.

But these are less tangible and from the project's point of view only a means towards the ultimate objective. Therefore the only benefit that will be estimated in the subsequent cost-benefit analysis is the value of so much grain saved on smallholder farms that would have been lost due to molds, insects, birds, and rodents if the project had not taken place.

These benefits are tangible, but, unlike the costs of the project, are not easy to estimate with a great deal of certainty. In order to do so, it is necessary to make assumptions about how many smallholder farmers adopt new postharvest practices in each year and how much grain each saves by adopting these new practices. These are assumptions on which reasonable people can reasonably disagree. Therefore, insofar as the assumptions which are made do justify the project, they should be interpreted as the assumptions that are necessary in order to justify the project. In other words, given the costs of the project, it is necessary to save so much grain on smallholder farms in order to make the project pay for itself and in order to save so much grain it is necessary to make assumptions at least equivalent to those that are made. The major part of section C below is concerned precisely with the assumptions necessary to save so much grain.

There is the question of what type of grains will be saved. Maize is the staple grain of Kenya but smallholders also grow beans, sorghum, millet, and peas. If implemented, the project should lead to a reduction in post-harvest losses of all these grains. Therefore there is an argument for estimating the amount of each grain saved as a result of project activities. However, the consultants believe that the project can pay for itself simply in terms of the amount of maize that is saved and since this represents something more than three-quarters of the grain that will be saved, the cost-benefit analysis below is simply conducted in terms of the amount of maize that is saved. To the extent that the project can pay for itself in terms of maize it will also be able to pay for itself in terms of other grains in addition. Maize is also the grain for which the consultants have the most reliable estimates of present losses and possible reductions in losses as a result of improved postharvest practices.

Then there is the question of what constitutes economic loss. In Table V-1, the consultants present their estimates of postharvest weight losses due to insects and molds. In the cost-benefit analysis, these are taken as direct economic losses. There are other losses discussed in Chapter IV.G. These include weight losses due to rodents that the consultants were unable to estimate, quality losses such as grain only partially damaged by insects, and perhaps most important of all the intangible loss associated with aflatoxin-infested grain. These are real losses but they are not readily quantifiable and are not included as economic losses in the cost-benefit analysis. Once again, to the extent that the project can pay for itself in terms of pure weight losses that are reduced, it will also be able to pay for itself in terms of these other losses in addition. The internal rates of return estimated in section D below should be considered conservative.

Finally, there is the question at what price to value maize that is saved. After consultation with GOK and USAID officials, it has been agreed to value maize at the import price, c.i.f. Mombasa, plus transportation to Nairobi. Over the last decade, Kenya has been roughly self-sufficient in maize, importing in some years and exporting in others. However, the supply of maize has been increasing less quickly than the demand (arising from both population and income growth, the former at 4.0 percent a year), and the prospect is for increasing imports over the coming decade. At the time of writing (1980), there is already an acute shortage of maize in the country which is likely to persist until after the next long rains harvest, and there are plans by the government to import maize this year. Therefore, from the point of view of GOK and USAID, the presumption is the maize saved as a result of the project is less maize that would have to be imported. As there is no prospect of importing maize from neighboring African countries, this maize would have to be imported through Mombasa and transported to Nairobi (as a central location representative of Kenya as a whole).

4. Shadow Pricing

There is almost no need for shadow pricing in this project owing primarily to the nature of the project. So much of the project costs are for salaries and training of personnel. Commodity costs are relatively small and some of these are locally manufactured. The only cost in the entire analysis that is shadow-priced is the cost of transporting maize from Mombasa to Nairobi. This is because freight charges do not represent actual costs to GOK. Part of the freight charges are for government taxes on items such as fuel, and other part is revenue that accrues to GOK. Scott, MacArthur, and Newbury (1) estimate the shadow price of rail transport to be 0.67, which estimate is used in Section D below.

There are some foreign exchange commodity costs to GOK which could have been shadow priced but, again owing to the nature of the project, these are outweighed by foreign exchange benefits to GOK. For instance, the project provides for 16 person-years of expatriate technical assistance paid for by USAID. To the extent that these personnel spend money on local goods, an estimated $30,000 a year, this represents a foreign exchange benefit to GOK. The project also provides for USAID to pay some of the cost of farmer training, the cost of M.Sc. training in-country, salaries of Kenyan personnel involved in research, and salaries of two Kenyan administrative assistants, all of which represent foreign exchange benefits to GOK. Total foreign exchange benefits to GOK are estimated at $2.332 million in 1980 prices in the first five years of the project. On the other hand, GOK foreign exchange costs are estimated in Table VII-1 at only $1.293 million over the entire fifteen years. In other words, even at a social discount rate of zero percent, the project results in a net foreign exchange benefit to GOK of $1.039 million. Therefore, it was decided not to shadow price GOK foreign exchange costs.

Table VII-1. Estimated project costs to GOK by type of cost and project component
(KSh 1000's in 1980 prices)

	Project Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Kenyan Personnel															
(Project component)															
A. PHSS, MOA	153	632	613	947	1,262	1,463	1,603	1,742	1,882	2,021	2,161	2,300	2,440	2,440	2,440
B. Egerton	11	22	22	22	22	22	22	22	22	22	22	22	22	22	22
L. LDD, MOA	23	60	74	84	93	93	93	93	93	93	93	93	93	93	93
Sub-totals	187	714	709	1,033	1,377	1,578	1,718	1,857	1,997	2,136	2,276	2,415	2,555	2,555	2,555
Staff Training															
A. PHSS, MOA	-	19	-	41	41	-	-	-	-	-	-	-	-	-	-
F. Embu/Bukura	-	14	14	-	-	-	-	-	-	-	-	-	-	-	-
H. CBS	19	-	-	-	-	-	-	43	-	-	43	-	-	43	-
K. HEYD, MOA	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-
L. LDD, MOA	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-
Sub-totals	19	51	14	41	41	-	-	43	-	-	43	-	-	43	-
Commodities															
A. PHSS, MOA	117	187	199	217	264	304	520	304	316	520	558	304	520	304	316
B. FTC's	-	9	25	41	41	41	41	41	41	41	172	276	276	41	41
E. Egerton	-	3	3	3	3	17	17	17	17	17	112	17	17	17	17
F. Embu/Bukura	6	14	13	11	11	11	11	11	11	11	95	11	11	11	11
G. Univ. of Nairobi	3	7	11	9	8	8	8	8	8	8	84	84	8	8	8
H. CBS	-	-	-	-	-	-	-	212	-	-	212	-	-	212	-
J. AIC	-	-	-	-	-	342	342	342	342	342	342	342	342	342	342
L. LDD, MOA	-	6	1	1	1	1	1	1	1	1	1	24	11	1	1
Sub-totals	123	226	252	282	328	724	940	936	736	940	1,576	1,058	1,185	936	736
Farmer Training															
B. FTCs	-	132	348	433	433	1,590	1,590	1,590	1,590	1,590	1,590	1,590	1,590	1,590	1,590
GRAND TOTALS	329	1,123	1,323	1,789	2,179	3,892	4,248	4,426	4,323	4,666	5,485	5,063	5,330	5,124	4,881
USAID costs (Ksh 1000)	6,438	11,544	12,528	9.905	6,600	-	-	-	-	-	-	-	-	-	-
TOTAL PROJECT COSTS	6,767	12,667	13,851	11,694	8,779	3,892	4,248	4,426	4,323	4,666	5,485	5,063	5,330	5,124	4,881
Estimated foreign exchange component of GOK costs (1000 $US)	3	14	19	24	30	87	117	116	80	117	202	127	145	116	88

5. Use of Constant vs. Current Prices

The entire cost-benefit analysis is carried out in constant 1980 prices. In general, the only reason for allowing for inflation in cost-benefit analysis is if some prices are likely to increase more rapidly than others, rather than all prices going up at the same rate. Although there is a presumption that over fifteen years fuel costs will increase more rapidly than, say, Kenyan salaries, it is judged that the increased complexity in allowing for differential rates of inflation in the analysis would scarcely improve the precision of the internal rates of return calculated in section D below. Therefore, for simplicity, the entire analysis is conducted in constant prices.

B. Estimation of Costs

1. Introduction

USAID and GOK costs for the first five years of the project have already been estimated in Chapter VI. In this section, it is now necessary to estimate GOK costs for project years six to fifteen. These estimates are presented in Table VII-1 by type of cost and project component. At the bottom of the table, USAID costs are added to GOK costs to derive the total project costs.

In order to derive these estimates, it was necessary to make some assumptions about the continuing nature of the project from year six onwards. What follows is a brief description of these assumptions.

2. Kenyan Personnel

Costs for Kenyan personnel are only incurred in project components A, E, and L. At Egerton College and in the Land Development Division, it is assumed that no new positions will be created after project year five. Therefore costs continue as in year five. It is also assumed that, as in years four and five, three additional positions for District Postharvest and Storage Officers will be created each year from year six to year 13 by which time 30 positions will have been created. These DPHSO's are needed in order to support the efforts of extension personnel in extending postharvest and storage technology to farmers. Although they will concentrate initially on the postharvest handling and storage of food grains, they will eventually turn their attention to other crops as well.

3. Staff Training

It is assumed that all USAID-funding staff training programs will be discontinued at the end of year five. The only additional staff training costs of GOK are for training CBS supervisors and enumerators in the

collection of grains samples in years 8, 11, and 14. It is assumed that the Central Bureau of Statistics will continue to conduct grain loss surveys every three years, as already provided for in years 2 and 5.

4. Commodities

Commodity costs are incurred under most project components and after project year five, these will have to be borne entirely by GOK. As a general rule, it is assumed that the nine vehicles supplied under the project will have to be replaced at the end of every six years and that all other commodities, with two exceptions, will have to be replaced at the end of ten years. The exceptions are the PHSS laboratory and the insectaries for the biology laboratory at Egerton College which it is assumed will not have to be rebuilt during the fifteen year life of the project. As is standard practice in cost-benefit analysis, the costs of new commodities are charged against the years in which they are replaced. The cost of depreciation is not charged against any years as this would represent double-counting.

For the Central Bureau of Statistics, it is assumed as above that commodity costs associated with grain loss surveys will be incurred in years 8, 11, and 14. For the Agricultural Information Center, it is assumed that commodity costs will continue in years six to 15 at the same level as in year five.

5. Farmer Training

In years four and five, the project already provides for 184 one-week courses at FTCs and 92 three-day courses at community centers, schools, churches, etc. Of these, the 84 courses offered in Western and Nyanza Provinces make participants eligible for a partial grant to construct a crib and a drying platform. After year five it is assumed that the partial grant component which was totally financed by USAID, will be discontinued by GOK. It is further assumed that in year six the relative number of residential courses at FTCs versus field courses at community centers will undergo a slight change, the former being reduced in half and the latter increasing by three times. There are two reasons for this assumption. First, there is already a great deal of pressure on FTC time and it is likely that after several years of devoting 8 out of 42 weeks to grain storage at each FTC, GOK will want to reallocate this time somewhat. Secondly, field courses which cost roughly half that of FTC courses are better value for the money. At the time of writing, the field courses represent very much of an experimental innovation which is why it is unrealistic to plan for any more in the first five years of the project, but by year six GOK should be in a position to expand them having gained the necessary experience to do so.

Table VII-2 details the precise number of farmer training courses expected to be held during the 15 years of the project.

Table VII-2. Farmer training courses to be held

Type of Course	Project Year 1	2	3	4	5	6	15
One-week FTC Courses	-	56	148	184	184	92.....	92
Those which lead to a partial grant	-	(28)	(56)	(56)	(56)	-.....	92
Three-day field courses	-	28	74	92	92	276....	276
Those which lead to a partial grant	-	(14)	(28)	(28)	(28)	-....	-

C. Estimation of Benefits

1. Value of Maize Saved

At the time of writing, the world price of maize is approximately $115 a metric ton at the Gulf Ports, U.S.A. According to officials at the National Cereals and Produce Board, cost of transportation and insurance to Mombasa is $50 a ton and the cost of rail transport to Nairobi is KSh 20 a bag. At 90 Kg to a bag and a shadow price of 0.67, the latter works out to approximately $20 a ton. Therefore, for the purposes of this project, maize that is saved is valued at $185 a ton or KSh 1,332 a ton. This price is almost identical to the peak season price at rural markets in Kenya in 1977-78.

2. Benefits That an Adopting Smallholder Receives

The consultants have estimated (Chapter V.E.) that the average maize-producer in Kenya loses 16.86 percent of his actual maize production at maturity to molds, insects, and birds. The consultants have also estimated that a farmer could reduce these losses to a mere 4.69 percent by adopting a package of practices which include harvesting at maturity, drying the maize down to 13% moisture on a drying platform, and treating half the maize with an insecticide. This represents the consultants' recommended post-harvest practices to smallholders maize producers in Kenya.

It is likely that some farmers impacted by the project will refuse to adopt any of these practices, others will adopt some of them, and still others all of them. This pattern of response arises from such things as different levels of maize production by smallholders, striking differences in climate

throughout Kenya which influence the relative benefits of different practices, and, of course, the psychology of the smallholder farmer. Because it is impossible to sort out the different response patterns and the different benefits derived from different responses, the remainder of the analysis concerns itself only with those farmers who adopt the entire package of recommendations.

This is not as arbitrary as it may sound. Gerhart (2) in his study of the diffusion of hybrid maize in Western Kenya found that the adoption of hybrid maize tended to be a (binary) process in which the adoption of hybrid maize tended to lead to the adoption of improved agronomic practices such as planting in rows and applying fertilizers. Similarly, one can argue that the adoption of an improved design crib and a drying platform will lead to earlier harvesting and appropriate treatment with insecticides in order to get the maximum benefit from the crib and the drying platform. It is also possible in the remaining analysis to compensate for the fact that not all farmers who adopt will adopt the complete package by being conservative with regard to the number of adopters.

A smallholder who adopts will almost certainly not achieve the ultimate reduction in grain losses during the first year of adoption. Rather it is more likely that he will undergo a learning process which a few years down the road will lead to the 72.2 percent reduction in losses from 16.86 percent to 4.69 percent. Therefore, it is assumed that the farmer who adopts has a learning curve as represented in the following table:

	Year of adoption					
	0	1	2	3	4	5
Grain loss (percent)	16.86	11.07	9.00	6.93	4.69	5.69...
Percentage reduction	0.0	34.3	46.6	58.9	72.2	72.2 ...

Before adoption he experiences losses of 16.86 percent. The first year he adopts, he simply builds a new crib and a drying platform, harvests at the same time as before (about 20 percent moisture content) and reduces his losses by 34.3 percent. The second year, he harvests somewhat earlier at 25 percent and the third year at the recommended practice of 35 percent. Finally in the fourth year, he has learned how to apply insecticides effectively and he is about to reduce his losses down to the objective of 4.69 percent. In all subsequent years, he maintains his losses at this level.

3. Number of Adopting Smallholders

The project provides for three different forms of face-to-face contact between extension personnel and farmers: courses leading to partial grants for cribs and drying platforms; one-week courses at FTCs; and three-day

courses at community centers, etc. Of each course leading to a partial grant, it is assumed that 2/3 of the 50 participants or 33.3 farmers will adopt; of the FTC courses, 1/3 of the 50 participants or 16.7 farmers; and of the field courses, 1/4 of the participants or 12.5 farmers. If fewer or more than 50 farmers attend each course, then the proportions assumed would change but the absolute numbers would remain the same. Thus if experience begins to show that only 25 farmers on average attend a three-day field training course, then it is assumed that one-half of the participants adopt.

Lest the point has been missed, it is important to note that the number of farmer training courses offered under the project is a crucial variable in producing sufficient benefits in order to pay for the project. In the way that benefits are estimated in this chapter, the research, the institutional backstopping, and training of extension personnel only produce benefits insofar as they lead to appropriate farmer training courses that induce farmers to adopt new postharvest practices.

4. The Spread Effect

Face-to-face contact between farmers and extension personnel at farmer training courses is not the only means of inducing farmers to adopt new postharvest practices. Farmers have neighbors with whom they discuss their farming methods. They attend meetings where agriculture is discussed. They visit and are in turn visited by extension personnel. They listen to radios. To a considerable degree, the importance of these other types of change-agents depends on the initiative and imagination shown by extension personnel at the location and sub-location level. The project does provide for activities of this kind, especially in the assistance that it gives to the Agricultural Information Center. It also institutionalizes a grain monitoring system at FTCs and an applied research and development capability at Egerton College and Embu/Bukura Institutes of Agriculture where the results will be directly evident to extension personnel. To the extent that these activities lead to more appropriate recommendations to farmers, especially recommendations that take into account regional variations throughout the country, the spread effect will be larger.

Although few will deny the existence of a spread effect as the "progressive" farmers adopt first and others follow, there are widespread opinions concerning its magnitude. For the purpose of estimating benefits, it is here assumed that for every farmer who adopts the entire package of postharvest recommendations as a result of attending a farmer training course, two of his neighbors will also adopt one year later.

As a result of the assumptions made, it is now possible to calculate the number of farmers who will adopt the recommended postharvest practices during the fifteen years of the project. These calculations are shown in Table VII-3. Out of 1.93 million smallholders in Kenya that grow maize, 2.27 percent will have adopted after 5 years, 6.22 percent after 10 years, and 10.09 percent after 15 years. Considering the magnitude of the effort being made in the proposed project, these percentages do not sound unreasonable. They might even be somewhat pessimistic.

Table VII-3. Number of smallholders adopting recommended postharvest practices

Reasons for adopting	Project Year 1	2	3	4	5	6	7	8	....	15	15-year Total
1. Received partial grant	-	1,400	2,800	2,800	2,800	-	-	-	....	-	9,800
2. Attended FTC course	-	467	1,533	2,133	2,133	1,533	1,533	1,533	....	1,533	21,600
3. Attended field course	-	175	575	800	800	3,450	3,450	3,450	....	3,450	36,850
4. Neighbor of (1)	-	-	2,800	5,600	5,600	5,600	-	-	....	-	19,600
5. Neighbor of (2)	-	-	933	3,067	4,267	4,267	3,067	3,067	....	3,067	40,133
6. Neighbor of (3)	-	-	350	1,150	1,600	1,600	6,900	6,900	....	6,900	66,800
Total		2,042	8,991	15,550	17,200	16,450	14,950	14,950		14,950	194,783
Cumulative total		2,042	11,033	26,583	43,783	60,233	74,183	90,133	....	194,783	194,783
Percent of smallholders in Kenya		0.11	0.57	1.38	2.27	3.12	3.90	4.67	....	10.09	10.09

5. Other Assumptions

In 1979, the Central Bureau of Statistics estimated that smallholders in Kenya produced 14.88 million bags of maize or an average of 7.71 bags each. The consultants believe that a farmer producing as little as 4 bags of maize a year will find it profitable to adopt the recommended practices. Still, if experience is any guide, the first farmers who adopt the recommended practices will on average produce more than 7.71 bags. It is here assumed that the average farmer who adopts produces 11.57 bags, or 50 percent more than the average. This is almost certainly a conservative assumption. In the initial project years, it will more than likely be larger than this, which would increase the flow of benefits from the project.

Finally, maize production in Kenya is not stationary. From a base of 14.88 million bags in 1979, it is assumed that maize production will increase at 2 percent per year, or more specifically that those farmers who adopt increase their maize production at 2 percent a year. This is below the long-term trend in Kenya over the last 15 years.

6. Total Estimated Benefits Arising from the Project

On the basis of the assumptions made, the average farmer who adopts and who produces 11.57 bags a year will save 0.67 bags of maize in the first year that he adopts, 0.91 bags the second year, 1.16 bags the third year, and 1.42 bags every year thereafter. Given the number of adopters as presented in Table VII-3, it is a simple matter to calculate maize savings as shown in Table VII-4. The estimated benefits to the project, based on all the assumptions m. ., are shown year by year on the bottom line of this table. The total benefits arising from the project by the end of 15 years is estimated at KSh 247.62 million or $US 34.39 million.

D. Project Worth

1. Estimated Internal Rate of Return and Net Present Value

The net benefits of the project can be obtained year by year by subtracting the estimated costs as they appear in Table VII-1 from the estimated benefits as they appear in Table VII-4. From the point of view of USAID, the project does not begin to yield net benefits until project year six which is the first year that estimated benefits outweigh total project costs, both USAID and GOK. The estimated internal rate of return to total project costs is 18.0 percent. The estimated net present value of the project at a discount rate of 15.0 percent is KSh 7.36 million or $US 1.02 million in constant 1980 prices. On this basis the consultants recommend that USAID should implement the proposed project as designed.

From the point of view of GOK, excluding USAID grant assistance from total costs, the project begins to yield net benefits in year four. The estimated internal rate of return to GOK costs alone is 93.9 percent. The estimated net present value at a discount rate of 15.0 percent is KSh 38.87 million or $US 5.40 million. The government of Kenya should scarcely hesitate to implement this project.

Table VII-4. Amount of maize saved by smallholders adopting recommended postharvest practices. (metric tons)

No. of adopters in each year	Project Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15-year total
1. -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. 2,042	-	123	167	213	261	261	261	261	261	261	261	261	261	261	261	3,374
3. 8,991		-	542	736	939	1,149	1,149	1,149	1,149	1,149	1,149	1,149	1,149	1,149	1,149	13,707
4. 15,550	-	-	-	938	1,274	1,623	1,987	1,987	1,987	1,987	1,987	1,987	1,987	1,987	1,987	21,718
5. 17,200	-	-	-	-	1,037	1,409	1,786	2,198	2,198	2,198	2,198	2,198	2,198	2,198	2,198	21,826
6. 16,450	-	-	-	-	-	992	1,347	1,717	2,102	2,102	2,102	2,102	2,102	2,102	2,102	18,770
7. 14,950	-	-	-	-	-	-	901	1,224	1,561	1,911	1,911	1,911	1,911	1,911	1,911	15,152
8. 14,950	-	-	-	-	-	-	-	901	1,224	1,561	1,911	1,911	1,911	1,911	1,911	13,241
9. 14,950	-	-	-	-	-	-	-	-	901	1,224	1,561	1,911	1,911	1,911	1,911	11,330
10. 14,950	-	-	-	-	-	-	-	-	-	901	1,224	1,561	1,911	1,911	1,911	9,419
11 14,950	-	-	-	-	-	-	-	-	-	-	901	1,224	1,561	1,911	1,911	7,508
12. 14,950	-	-	-	-	-	-	-	-	-	-	-	901	1,224	1,561	1,911	5,597
13. 14,950	-	-	-	-	-	-	-	-	-	-	-	-	901	1,224	1,561	3,686
14. 14,950	-	-	-	-	-	-	-	-	-	-	-	-	-	901	1,224	2,125
15. 14,950	-	-	-	-	-	-	-	-	-	-	-	-	-	-	901	901
Grand Total		123	709	1,987	3,511	5,434	7,441	9,437	11,383	13,294	15,205	17,116	19,027	20,938	22,849	148,354
Estimated amount saved @ 2% increase in production per year		128	752	2,043	3,876	6,120	8,547	11,057	13,604	16,205	18,906	21,707	24,613	27,627	30,752	185,937
Value in KSh 1000's		171	1,002	2,720	5,164	8,207	11,385	14,728	18,120	21,586	25,182	28,915	32,785	36,693	40,962	247,620

2. Sensitivity Analysis

The results presented in section 1 above are based on the numerous assumptions that have been made throughout this chapter. The project will pay for itself to the extent that these assumptions are realistic. Or alternatively, the rough magnitude of these assumptions are necessary in order for the project to pay for itself. This is particularly true of the assumptions concerning the rate of adoption and the amount of maize that each adopter saves over time. In this section the sensitivity of the above results to some of the assumptions are analyzed. The results of the sensitivity analyses are contained in Table VII-5.

a. No Growth in Maize Production Over Time

The basic case assumed that smallholder maize production would increase at 2 percent per year over the 15 years of the project. Maybe this is too optimistic or maybe production will increase only as a result of an increasing number of smallholdings not as a result of increasing productivity per smallholding. If no growth in productivity is assumed to occur, then the rate of return to total project costs is 13.9 percent and to GOK costs alone 85.1 percent.

b. Reduction in Maize Loss of Only 50 Percent Per Adopter

The basic case assumed that a smallholder who adopted the entire package of recommendations would utimately reduce his postharvest maize losses to 4.69 percent, equal to a reduction of 72.2 percent from the initial losses of 16.86 percent. Although the consultants believe that this is possible, this may be overly optimistic. Suppose that the learning curve remains the same as in the basic case but that the smallholder who adopts reduces his losses by only 23.8 percent in the first year of adoption, 32.3 percent in the second year, 40.8 percent in the their year, and 50.0 percent in every year thereafter. Then the rate of return to total project costs is only 10.6 percent and to GOK costs alone 65.6 percent. That the rate of return to total project costs falls to 10.6 percent is a measure of the importance of appropriate recommendations that really will reduce grain losses by as much as 72.2 percent. In a certain sense, the difference between 10.6 and 18.0 percent can be viewed as a return to the research that is financed under the project and points out the need for this research to be included in the project.

c. A Smaller Spread Effect

The basic case assumed that for each farmer who adopted the package of postharvest recommendations as a result of attending a farmer training course, two of his neighbors would adopt one year later. This may also be overly optimistic. On the assumption that only one neighbor adopts, then the rate of return to total project costs is 10.4 percent and to GOK costs alone 69.2 percent. The points out the importance of the spread effect and the importance of change-agents other than farmer training courses. For the project to pay for itself, the recommendations must also be communicated in other ways such as local meetings, extension visits, and on the radio. Thus the support that the project gives to these activities is also significant.

Table VII-5. Rate of return to project over 15 years, under various assumptions

Assumptions concerning project benefits	Percent adoption after			Internal rate of return	
	5 years	10 years	15 years	to GOK	to GOK & USAID
1. Basic case as outlined in section C	2.27	6.22	10.09	93.9	18.0
2. Basic case with no growth in maize production over time	2.27	6.22	10.09	85.1	13.9
3. Basic case with ultimate reduction in grain loss of only 50.0%	2.27	6.22	10.09	65.6	10.6
4. Basic case but only one neighbor adopts	1.61	4.23	6.81	69.2	10.4
5. One-half of FTC trainees and 40% of field trainees adopt	2.81	8.84	14.91	113.8	24.6

d. A Higher Rate of Adoption by Trainees

The basic case assumed that 1/3 of farmers attending FTC courses would adopt as well as ¼ of farmers attending three-day courses. This may be overly pessimistic. If the proportions are increased to ½ and 4/10 respectively, then the rate of return to total project costs increases to 24.6 percent and to GOK costs alone 113.8 percent. This is a significant increase that points out the importance of appropriate teaching at farmer training courses. The more appropriate the teaching and the more relevant the recommendations from the farmer's point of view, the larger the number of farmers that will adopt. In a certain sense, the difference between 18.0 and 24.6 percent is a measure of the return to the support that the project provides to the agricultural extension service, including the training of extension personnel, assistance to Embu/Bukura, assistance to Egerton College, and the establishment of a Post-Harvest and Storage Section within the Ministry of Agriculture.

3. Additional Remarks

In all the cases presented above, the rate of return to GOK costs alone is at least 65 percent. Thus the worth of the project from the point of view of the Government of Kenya should not be in doubt, simply in terms of reducing the amount of maize imports that might otherwise be required if the project is not implemented. At a time when the long run prospects for self-sufficiency in maize production look worse than in the past, the project deserves serious consideration.

The consultants believe that the project can pay for itself simply in terms of the amount of maize saved in kilograms that would otherwise be lost on smallholder farms to insects and molds. But there are still other reasons why the consultants recommend that both GOK and USAID implement the project. These include the quality and other intangible losses discussed in section A.3. above. Clearly, the most important of these is the alarmingly high incidence of aflatoxin that the team found in maize samples collected throughout the country. It is impossible to measure accurately the benefit that Kenya would receive in terms of the improved health of its citizens from a reduction in this high incidence of aflatoxin, but there should be no doubt that these benefits are enormous and taken alone could conceivably justify the project. The team's findings correlate closely with those of health practitioners who report from clinical studies a correspondingly high rate of liver cancer.

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APPENDICES

APPENDIX CHAPTER II

A. Typical Weather Data in Four Provinces

B. Storage and Disposal of Maize

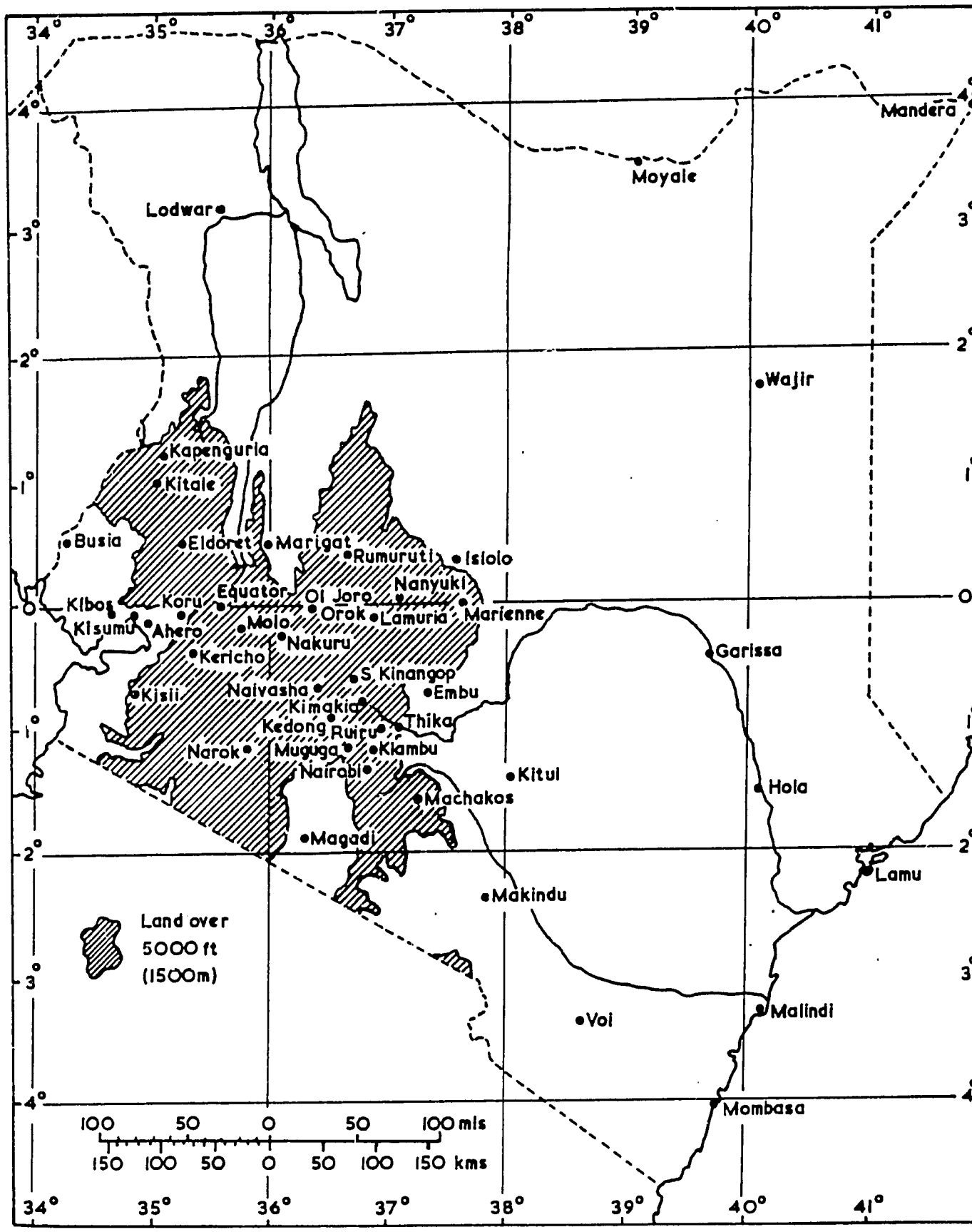


Fig. 1 Map of Kenya showing stations

STATION NAME KIBOS, COTTON EXPERIMENTAL STATION.

STATION NUMBER 90.34/081

LATITUDE 00°03'S LONGITUDE 34°48'E

ALTITUDE 3847 FEET (1173 METRES)

MONTH	TEMPERATURE (1959–70) MEANS MAX.	MEANS MIN.	MEANS RANGE	EXTREMES HIGHEST	EXTREMES LOWEST	DRY BULB 0600 GMT	DRY BULB 1200 GMT	DEW POINT 0600 GMT	DEW POINT 1200 GMT	RELATIVE HUMIDITY 0300 GMT	RELATIVE HUMIDITY 0600 GMT	RELATIVE HUMIDITY 1200 GMT	RAINFALL (1952–70) MEAN	RAINFALL HIGHEST	RAINFALL LOWEST	MAX. 24-HOUR FALL*
	°C	°C	°C	°C	°C	°C	°C	°C	°C	%	%	%	mm	mm	mm	mm
January	30.8	15.3	15.5	36.7	10.0	21.8	27.4	13.8	12.9		60	36	65	222	5	71.4
February	30.7	15.7	15.0	35.6	11.1	21.6	28.9	14.6	14.3		65	41	91	231	32	49.5
March	29.5	16.2	13.3	36.1	13.3	21.7	28.3	15.7	15.1		69	44	164	241	104	72.2
April	28.1	16.7	11.4	33.3	13.3	21.5	26.9	16.4	16.0		73	52	223	359	62	108.5
May	27.8	16.4	11.4	30.6	11.7	21.4	26.1	16.2	15.7		73	52	150	317	77	68.6
June	28.0	15.1	12.9	31.1	11.1	20.5	26.9	14.9	14.3		71	46	73	140	26	50.3
July	27.8	14.9	12.9	30.6	10.0	19.8	26.7	14.4	13.2		71	44	57	81	12	37.6
August	28.3	14.7	13.6	32.2	11.0	20.1	27.0	14.0	13.0		68	42	90	222	27	81.3
September	28.9	14.9	14.0	33.5	11.1	21.1	27.1	14.1	13.1		64	42	83	114	7	47.5
October	29.6	15.4	14.2	35.0	11.1	22.1	27.4	14.4	13.9		61	43	74	112	38	34.8
November	29.2	15.8	13.4	34.4	11.1	22.0	27.1	15.1	14.8		65	47	124	200	64	58.2
December	29.6	15.2	14.4	34.5	11.1	21.9	28.3	14.4	13.9		62	41	93	190	23	61.2
Year	29.0	15.5	13.5	36.7	10.0	21.3	27.5	14.8	14.2		67	44	1287	1452	916	108.5

*1962–70

MONTH	NUMBER OF DAYS OF RAIN ≥1mm	THUNDER	DAILY SUNSHINE (1963–70) MEAN	MAX. MEAN	MIN. MEAN	DAILY RADIATION (1963–70) INSTRUMENT GB MEAN	MAX. MEAN	MIN. MEAN	MONTHLY EVAPORATION (1959–70) PAN TYPE A MEAN	HIGHEST	LOWEST	CLOUD AMOUNT ( ) TOTAL 0600 GMT	TOTAL 1200 GMT	LOW 0600 GMT	LOW 1200 GMT	DAILY WIND RUN (1964–70)	WIND SPEED ( ) 0600 GMT	1200 GMT	CALMS ( ) 0600 GMT	1200 GMT
	≥1mm	days	hours	hours	hours	langleys	langleys	langleys	mm	mm	mm	oktas	oktas	oktas	oktas	miles	knots	knots	days	days
January	6		9.1	10.3	6.9	655	693	602	234	306	176					98.4				
February	9		8.8	10.0	6.7	644	684	566	213	259	166					99.1				
March	13		8.3	9.2	6.0	634	676	551	209	254	149					92.0				
April	17		7.2	9.7	5.4	593	628	517	170	202	127					73.5				
May	13		7.5	8.5	6.6	583	610	563	157	176	133					67.1				
June	7		8.3	9.1	7.5	575	597	554	160	196	136					68.8				
July	7		7.2	8.4	6.7	543	566	509	159	175	133					67.3				
August	10		7.3	8.3	5.7	557	588	523	171	187	157					75.3				
September	8		7.9	9.1	6.7	624	642	592	183	213	162					80.8				
October	11		7.8	8.4	7.2	625	665	585	196	231	159					81.3				
November	13		7.5	8.1	6.9	598	617	557	180	213	128					80.9				
December	9		8.7	9.6	6.4	636	672	537	206	256	157					92.7				
Year	123		8.0	8.5	7.5	606	624	583	2238	2357	2008					81.4				

STATION NAME MACHAKOS, KATUMANI EXPERIMENTAL FARM

STATION NUMBER 91.37/089

LATITUDE 01°35'S LONGITUDE 37°14'E

ALTITUDE 5250 FEET (1601 METRES)

MONTH	TEMPERATURE (1965–70) MEANS MAX.	MEANS MIN.	MEANS RANGE	EXTREMES HIGHEST	EXTREMES LOWEST	DRY BULB 0600 GMT	DRY BULB 1200 GMT	DEW POINT 0600 GMT	DEW POINT 1200 GMT	RELATIVE HUMIDITY 0300 GMT	RELATIVE HUMIDITY 0600 GMT	RELATIVE HUMIDITY 1200 GMT	RAINFALL (1958–70) MEAN	RAINFALL HIGHEST	RAINFALL LOWEST	RAINFALL MAX. 24-HOUR FALL
	°C	°C	°C	°C	°C	°C	°C	°C	°C	%	%	%	mm	mm	mm	mm
January	26.5	13.8	12.7	30.0	8.9	19.1	24.3	14.8	13.6		76	52	37	94	0	52.0
February	28.1	14.5	12.6	31.1	10.0	19.5	25.2	15.1	14.2		77	50	44	76	0	31.5
March	26.0	16.0	10.0	31.1	10.0	19.5	24.1	16.1	15.3		81	58	96	216	34	63.5
April	24.7	15.6	9.1	28.3	10.0	18.7	22.7	16.4	16.2		87	67	137	285	26	82.5
May	24.7	14.2	10.5	30.3	7.8	18.2	22.7	14.8	14.7		80	60	74	151	12	58.2
June	23.6	12.1	11.5	28.9	6.7	16.6	21.6	12.8	12.9		78	58	8	25	0	19.3
July	22.2	11.8	10.4	27.8	6.1	15.7	20.3	12.0	11.9		78	58	4	10	0	1.6
August	22.9	11.7	11.2	30.0	5.6	15.8	21.1	12.1	11.9		79	56	3	11	0	7.6
September	25.5	12.2	13.3	30.6	6.3	17.5	23.8	12.7	10.9		74	44	4	17	0	17.5
October	26.5	13.9	12.6	31.1	6.7	18.7	24.7	13.3	11.6		72	44	40	136	0	86.9
November	23.9	14.9	9.0	28.9	11.1	17.9	22.1	15.2	14.4		84	61	184	463	34	186.9
December	24.6	14.1	10.5	29.4	10.0	18.7	22.9	15.0	14.1		79	58	95	262	12	46.7
Year	24.9	13.7	11.2	31.1	5.6	18.0	23.0	14.2	13.5		79	55	726	1263	450	186.9

*1962–70

MONTH	NUMBER OF DAYS OF RAIN	NUMBER OF DAYS OF THUNDER	DAILY SUNSHINE ( ) MEAN	DAILY SUNSHINE MAX. MEAN	DAILY SUNSHINE MIN. MEAN	DAILY RADIATION (1965–70) INSTRUMENT GB MEAN	DAILY RADIATION MAX. MEAN	DAILY RADIATION MIN. MEAN	MONTHLY EVAPORATION ( ) PAN TYPE MEAN	MONTHLY EVAPORATION HIGHEST	MONTHLY EVAPORATION LOWEST	CLOUD AMOUNT ( ) TOTAL 0600 GMT	CLOUD AMOUNT TOTAL 1200 GMT	CLOUD AMOUNT LOW 0600 GMT	CLOUD AMOUNT LOW 1200 GMT	DAILY WIND RUN (1955–70)	WIND SPEED ( ) 0600 GMT	WIND SPEED 1200 GMT	CALMS ( ) 0600 GMT	CALMS 1200 GMT
	≥1mm	days	hours	hours	hours	langleys	langleys	langleys	mm	mm	mm	oktas	oktas	oktas	oktas	miles	knots	knots	days	days
January	4					548	576	487								111.2				
February	3					537	602	473								108.2				
March	7					509	569	372								99.0				
April	11					427	536	335								77.2				
May	7					409	495	320								61.0				
June	1					398	461	340								60.3				
July	1					334	390	251								57.1				
August	1					340	400	209								69.0				
September	0					474	505	435								90.2				
October	3					494	555	441								113.8				
November	14					430	471	354								109.3				
December	8					511	558	441								107.5				
Year	60					451	499	388								88.7				

STATION NAME LAMURIA W.D.D. STATION NUMBER 90.36/260

LATITUDE 00°08'S LONGITUDE 36°52'E ALTITUDE 6100 FEET (1860 METRES)

MONTH	TEMPERATURE (1963–70) MEANS MAX	MEANS MIN.	MEANS RANGE	EXTREMES HIGHEST	EXTREMES LOWEST	DRY BULB 0600 GMT	DRY BULB 1200 GMT	DEW POINT 0600 GMT	DEW POINT 1200 GMT	RELATIVE HUMIDITY 0300 GMT	RELATIVE HUMIDITY 0600 GMT	RELATIVE HUMIDITY 1200 GMT	RAINFALL (1965–70) MEAN	RAINFALL HIGHEST	RAINFALL LOWEST	RAINFALL MAX 24 HOUR FALL
	°C	°C	°C	°C	°C	°C	°C	°C	°C	%	%	%	mm	mm	mm	mm
January	25.8	5.6	20.2	31.4	0.6	17.0	22.3	11.4	11.5		70	49	54	116	0	31.5
February	26.1	6.8	19.3	30.3	1.9	16.5	23.5	11.5	12.8		73	51	60	138	9	32.0
March	25.6	7.8	17.8	29.8	1.1	16.8	22.0	13.5	13.2		77	57	124	160	69	49.3
April	24.5	11.5	13.0	29.4	0.6	17.4	21.2	14.3	14.7		82	66	154	251	74	59.7
May	23.8	12.5	11.3	29.4	4.4	16.8	21.0	13.9	14.3		83	65	43	56	14	34.5
June	23.2	11.0	12.2	31.1	1.7	15.6	21.1	12.2	13.6		81	62	39	72	2	26.2
July	21.9	11.2	10.7	27.2	5.0	14.8	19.9	11.8	11.9		82	61	26	59	7	30.7
August	22.4	10.5	11.9	29.7	1.7	14.6	19.8	11.4	12.4		81	63	19	77	0	23.4
September	24.8	10.7	14.1	30.8	4.9	16.2	21.7	11.4	11.0		74	51	20	32	4	21.1
October	25.2	10.6	14.6	29.2	4.3	17.3	21.2	12.7	11.6		75	54	56	128	28	29.2
November	23.5	9.3	14.2	27.2	2.2	17.0	20.1	13.1	13.2		78	64	119	165	68	56.1
December	24.0	6.5	17.5	29.0	1.1	17.8	21.6	12.0	11.2		69	52	44	105	3	62.2
Year	24.2	9.5	14.7	31.4	0.6	16.5	21.3	12.4	12.6		77	58	758	995	495	62.2

MONTH	NUMBER OF DAYS OF RAIN	NUMBER OF DAYS OF THUNDER	DAILY SUNSHINE ( ) MEAN	DAILY SUNSHINE MAX. MEAN	DAILY SUNSHINE MIN. MEAN	DAILY RADIATION (1963–70) INSTRUMENT GB MEAN	DAILY RADIATION MAX. MEAN	DAILY RADIATION MIN MEAN	MONTHLY EVAPORATION (1963–70) PAN TYPE A MEAN	MONTHLY EVAPORATION HIGHEST	MONTHLY EVAPORATION LOWEST	CLOUD AMOUNT ( ) TOTAL 0600 GMT	CLOUD AMOUNT TOTAL 1200 GMT	CLOUD AMOUNT LOW 0600 GMT	CLOUD AMOUNT LOW 1200 GMT	DAILY WIND RUN (1963–70)	WIND SPEED ( ) 0600 GMT	WIND SPEED 1200 GMT	CALMS ( ) 0600 GMT	CALMS 1200 GMT
	≥1mm	days	hours	hours	hours	langleys	langleys	langleys	mm	mm	mm	oktas	oktas	oktas	oktas	miles	knots	knots	days	days
January	6					539	621	460	152	198	124					83.5				
February	6					520	563	466	150	191	118					83.0				
March	11					500	534	461	158	188	1[illegible]1					79.9				
April	10					492	603	438	135	143	127					86.5				
May	5					537	608	494	154	171	14[illegible]					123.7				
June	3					527	601	400	159	181	144					136.5				
July	4					504	53[illegible]	420	154	175	106					142.0				
August	3					509	59[illegible]	408	165	183	145					151.5				
September	4					544	60[illegible]	445	193	203	182					150.1				
October	8					484	551	364	179	198	169					118.8				
November	12					421	470	304	120	134	109					84.6				
December	5					509	612	373	140	162	103					77.0				
Year	76					507	551	462	1859	1977	1793					109.8				

STATION NAME KERICHO, TIMILIL T.R.I.

STATION NUMBER 90.35/244

LATITUDE 00°22'S LONGITUDE 35°21'E

ALTITUDE 7000 FEET (2134 METRES)

MONTH	TEMPERATURE (1963–70) MEANS MAX.	MEANS MIN.	MEANS RANGE	EXTREMES HIGHEST	EXTREMES LOWEST	DRY BULB 0600 GMT	DRY BULB 1200 GMT	DEW POINT 0600 GMT	DEW POINT 1200 GMT	RELATIVE HUMIDITY 0300 GMT	RELATIVE HUMIDITY 0600 GMT	RELATIVE HUMIDITY 1200 GMT	RAINFALL (1964–70) MEAN	RAINFALL HIGHEST	RAINFALL LOWEST	RAINFALL HIGHEST 24 HOURFALL
	°C	°C	°C	°C	°C	°C	°C	°C	°C	%	%	%	mm	mm	mm	mm
January	24.0	8.7	15.3	27.5	2.5	17.0	21.7	9.2	9.7		60	47	78	289	14	47.3
February	23.8	9.1	14.7	29.0	2.8	16.7	21.1	10.4	10.7		67	51	114	226	10	41.4
March	23.6	9.5	14.1	27.7	5.6	16.7	20.8	11.2	11.5		70	56	129	321	120	58.9
April	22.3	10.1	12.2	26.2	6.1	16.5	18.7	12.2	13.5		77	73	275	482	114	79.3
May	22.1	9.6	12.5	28.5	6.0	16.5	18.2	12.3	13.6		77	74	262	455	120	70.0
June	21.3	8.7	12.6	27.9	4.5	15.5	18.3	11.4	12.5		77	68	202	282	128	53.4
July	20.5	9.1	11.4	21.0	5.5	14.7	17.7	11.3	12.0		81	70	199	334	118	62.7
August	20.7	8.9	11.8	25.0	5.6	15.4	17.3	11.1	11.9		76	71	212	340	45	57.2
September	21.9	8.4	13.5	26.6	5.4	16.9	18.5	10.9	11.4		68	63	172	223	107	57.1
October	22.1	8.8	13.3	26.3	4.2	17.3	18.6	11.1	12.0		66	65	168	208	119	30.4
November	21.9	9.5	12.4	25.6	5.6	17.1	18.6	11.4	12.2		69	67	131	222	70	37.2
December	22.7	8.6	14.1	27.3	5.0	17.0	20.1	10.5	10.7		65	53	80	129	8	48.8
Year	22.2	9.1	13.1	29.0	2.5	16.4	19.1	11.1	11.8		71	63	2081	2555	1583	79.3

MONTH	NUMBER OF DAYS OF RAIN	NUMBER OF DAYS OF THUNDER	DAILY SUNSHINE (1963–70) MEAN	DAILY SUNSHINE MAX. MEAN	DAILY SUNSHINE MIN. MEAN	DAILY RADIATION (1958–70) INSTRUMENT GB MEAN	DAILY RADIATION MAX. MEAN	DAILY RADIATION MIN. MEAN	MONTHLY EVAPORATION (1963–70) PAN TYPE A MEAN	MONTHLY EVAPORATION HIGHEST	MONTHLY EVAPORATION LOWEST	CLOUD AMOUNT ( ) TOTAL 0600 GMT	CLOUD AMOUNT TOTAL 1200 GMT	CLOUD AMOUNT LOW 0600 GMT	CLOUD AMOUNT LOW 1200 GMT	DAILY WIND RUN (1963–70)	WIND SPEED ( ) 0600 GMT	WIND SPEED 1200 GMT	CALMS ( ) 0600 GMT	CALMS 1200 GMT
	>1mm	days	hours	hours	hours	langleys	langleys	langleys	mm	mm	mm	oktas	oktas	oktas	oktas	miles	knots	knots	days	days
January	8		8.3	9.8	5.7	551	638	428	151	178	112					91.8				
February	11		7.5	9.5	4.9	551	664	417	131	161	101					84.8				
March	15		7.2	8.7	5.1	538	625	450	144	169	116					81.6				
April	21		5.6	8.0	4.2	443	505	362	106	137	78					67.7				
May	22		6.3	7.6	4.0	440	534	366	105	124	87					70.8				
June	20		7.0	8.3	4.9	458	544	385	106	121	82					81.0				
July	20		5.8	6.7	4.9	414	478	370	100	113	88					79.3				
August	21		5.7	6.7	4.1	418	480	344	103	121	87					85.7				
September	19		6.5	7.5	5.0	454	492	389	115	130	93					87.0				
October	21		6.3	7.1	5.2	439	504	375	111	127	96					81.3				
November	15		5.9	6.7	5.1	431	517	356	101	118	87					80.9				
December	11		7.5	8.9	5.0	498	583	414	123	141	108					80.7				
Year	204		6.6	7.7	6.2	470	492	438	1396	1468	1324					81.0				

B. Storage and Disposal of Maize

Table A-II-1. Estimates by province of storage and disposal of maize on smallholdings (in '000's of bags)

Month	In store beginning of month	Disposed of during month	Remained at end of month
	RIFT VALLEY PROVINCE		
0-1	7,000	494	6,506
1-2	6,506	801	5,705
2-3	5,705	581	5,124
3-4	5,124	1,089	4,034
4-5	4,034	1,258	2,777
5-6	2,777	844	1,994
6-7	1,993	300	1,633
7-8	1,633	210	1,423
8-9	1,423	404	1,020
9-10	1,020	415	604
10-11	604	498	106
11-12	106	106	0
	EASTERN PROVINCE		
0-1	1,940	320	1,620
1-2	1,620	414	1,206
2-3	1,206	279	928
3-4	928	460	468
4-5	468	369	99
5-6	99	71	28
6-7	28	28	0
7-12	0	0	0
	CENTRAL PROVINCE		
0-1	1,930	647	1,283
1-2	1,283	468	815
2-3	815	317	498
3-4	498	144	354
4-5	354	71	283
5-6	283	120	163
6-7	163	64	99
7-8	99	43	55
8-9	55	19	36
9-10	36	36	0
10-12	0	0	0
	NYANZA PROVINCE		
0-1	1,900	569	1,331
1-2	1,331	409	922
2-3	922	288	633
3-4	633	162	471
4-5	471	223	248
5-6	248	238	10
6-7	10	10	0
7-12	0	0	0
	WESTERN PROVINCE		
0-1	1,720	278	1,442
1-2	1,442	446	996
2-3	996	315	681
3-4	681	247	434
4-5	434	310	124
5-6	124	106	18
6-7	18	18	0
7-12	0	0	0

Source: Integrated Rural Survey - IV, 1978-79.
Unpublished data by Central Bureau of Statistics

APPENDIX CHAPTER III

A. Smallholder Questionnaire

B. Laboratory Methodology

C. Laboratory Data Sheet

D. Determination of Weight Loss

E. Estimation of Insect Weight Loss by Counting

F. Aflatoxin Assay Procedure

A. Smallholder Questionnnaire

Name of enumerator:_____ Date:_____
Name of farmer:_____ Man:_____ Woman:_____
Location Number:_____ Ident. Number:_____

Section I: INTRODUCTION

Data for the first four tables will be obtained from information gathered on previous visits to the farmer. Wherever possible, data will be obtained for those harvests which have occurred within the last calendar year prior to the date of the interview.

LOCAL MAIZE

	Long Rains 1978	Short Rains 1978	Long Rains 1979
Amount of land cultivated			
Pure stands	_____	_____	_____
Mixed stands	_____	_____	_____
Month of harvest	_____	_____	_____
Amount harvested (bags)	_____	_____	_____ (forecast)

HYBRID MAIZE

	Long Rains 1978	Short Rains 1978	Long Rains 1979
Amount of land cultivated			
Pure stands	_____	_____	_____
Mixed stands	_____	_____	_____
Month of harvest	_____	_____	_____
Amount harvested (bags)	_____	_____	_____ (forecast)

BEANS

	Long Rains 1978	Short Rains 1978	Long Rains 1979
Amount of land cultivated			
Pure stands	_____	_____	_____
Mixed stands	_____	_____	_____
Month of Harvest	_____	_____	_____
Amount harvested (bags)	_____	_____	_____

SORGHUM/MILLET

	Long Rains 1978	Short Rains 1978	Long Rains 1979
Amount of land cultivated			
Pure stands	_____	_____	_____
Mixed stands	_____	_____	_____
Month of harvest	_____	_____	_____
Amount harvested (bags)	_____	_____	_____

Section II: SELECTION OF SAMPLES

We are conducting a survey for the Ministry of Agriculture of on-farm storage practices and storage losses of food crops in Kenya. We would like to ask the farmer some questions about storage practices and losses on his farm, and if he has any maize, beans, sorghum or millet in his store from his last harvest of each crop, we would like to purchase some. The information will be used to help reduce storage losses in Kenya.

(Note to enumerator: For questions with yes-no answers circle Yes or No. For questions requiring a check-mark answer, place the check-mark in the space following the category to be checked. Ask questions only about crops grown on this farm. Ignore blanks corresponding to crops about which questions are not asked. If the farmer grew only local or hybrid maize exclusively, also ignore the blanks corresponding to the variety not grown. Also in the remainder of the questionnaire, sorghum and millet are generally treated as one crop. If both crops are grown on this farm, then place the answer for both crops in the single blank space provided, separated by a comma).

1. How much of each crop did you harvest in the long rains season of 1979? (Note to enumerator: If the crop is not yet harvested, write NH).

Local maize_____Bags Hybrid maize_____Bags
Beans_____Bags Sorghum/Millet_____Bags

2. Do you have any grain in storage from your last harvest, either in storage or in your house?

Local maize_____Hybrid maize_____
Beans_____Sorghum/Millet_____

(Note to enumerator: At this point, it is necessary for the team to decide what samples of grain are wished to be purchased and then to make an offer in shillings for each sample. It is also necessary to decide for which crops to continue asking questions of the respondent. After this decision has been made, then inform the respondent that the following questions refer only to maize, beans, sorghum, and/or millet as the case may be. The following questions refer only to):

Maize_____Beans_____Sorghum_____Millet_____

Section III: DRYING AND STORAGE

1. Do you generally harvest your crops

	Local maize	Hybrid maize	Beans	Sorghum/Millet
Before they are dried in the field?	_____	_____	_____	_____
After they are dried in the field?	_____	_____	_____	_____

2. (Note to enumerator: Ask this question only if crops are harvested before they are dried in the field).

(a) How do you generally dry your crops:

	Local maize	Hybrid maize	Beans	Sorghum/ Millet
On the ground	_____	_____	_____	_____
On platform/rack	_____	_____	_____	_____
From a pole or tree	_____	_____	_____	_____
On mats	_____	_____	_____	_____
In crib	_____	_____	_____	_____
Artificial	_____	_____	_____	_____

(b) In what form do you generally dry your crops?

	Local maize	Hybrid maize	Beans	Sorghum/ Millet
Ear with sheath	_____	_____		
Ear only	_____	_____		
Shelled	_____	_____	_____	_____
Pot or Head			_____	_____

(c) How many days does it generally take to dry your crops in this manner?

Local maize_____days Hybrid maize_____days
Beans_____days Sorghum/Millet_____days

3. In what form do you generally store your grain?

	Local maize	Hybrid maize	Beans	Sorghum/ Millet
Ear with sheath	_____	_____		
Ear only	_____	_____		
Shelled	_____	_____	_____	
Pod			_____	
Unthreshed				_____
Threshed				_____

4. (Note to enumerator: Ask this question only if the grain is stored as shelled/threshed)

(a) How is the grain shelled/threshed?

	Local maize	Hybrid maize	Beans	Sorghum/ Millet
Hand	_____	_____	_____	_____
Hand machine	_____	_____	_____	_____
Powered machine	_____	_____	_____	_____
Flail on threshing floor	_____	_____	_____	_____
Beating in a sack	_____	_____	_____	_____
Animal trampling	_____	_____	_____	_____
Other, specify	_____	_____	_____	_____

(b) Who does the shelling/threshing?

	Local maize	Hybrid maize	Beans	Sorghum/ Millet
Husband	_____	_____	_____	_____
Wife	_____	_____	_____	_____
Children	_____	_____	_____	_____
Other, specify	_____	_____	_____	_____

(c) How long did it take you to shell/thresh your grain?

	Number of days	Average hours per day
Local maize	_____	_____
Hybrid maize	_____	_____
Beans	_____	_____
Sorghum/Millet	_____	_____

5. Was the stored grain protected against insects in any way?

	Local maize	Hybrid maize	Beans	Sorghum/ Millet
Not protected	_____	_____	_____	_____
Dusted with: Phostoxin; Malathion; DDT; BHC; Ashes	_____	_____	_____	_____
Sprayed with: Phostoxin; Malathion; DDT; BHC	_____	_____	_____	_____

6. If yes, when was it protected?

	Local maize	Hybrid maize	Beans	Sorghum/ Millet
At storage (check)	_____	_____	_____	_____
Since storage (dates)	_____	_____	_____	_____

7. Was there any loss or spoilage to the grain before you put it into storage?

	Local maize	Hybrid maize	Beans	Sorghum/ Millet
(a) By rats	_____	_____	_____	_____
By birds	_____	_____	_____	_____
By molds	_____	_____	_____	_____
(b) None	_____	_____	_____	_____
A small amount	_____	_____	_____	_____
A large amount	_____	_____	_____	_____

Section IV: STORAGE FACILITIES

1. (a) What type of storage facilities do you have?

Cribs_____ Muddied cylinders_____ Bricks_____
Baskets_____ Bags_____ Jars_____ Boxes_____
Racks_____ Cans/drums_____ Other, specify_____

2. (Note to interviewer: Ask this question only if some grain is stored in bags).

(a) How many bags do you currently own for storing grain?_____
(b) How many bags do you generally buy each year?_____

3. (Note to interviewer: Ask this question only if there are containers other than bags).

(a) Type of container_____ _____ _____
(b) If purchased, how much did it cost?_____KSh _____KSh _____KSh
(c) If you made it, how long did it take you to make it? _____man days _____man days _____man days

4. (a) Where are the major stores located?

Outside the house_____ Inside the house_____
(b) If outside the house, are grains usually stored:
In one single structure_____? In different structures_____?

5. (a) How many stores do you have?_____
   (b) How old are they?_____Years
   (c) How many more years do you expect to use them?_____
   (d) In what month of the year did you build your stores?_____

ROOF OF CRIB OR TRADITIONAL STORE

(Note to interviewer: Check what the roof(s) are made of. Thatch_____ Bamboo_____Metal_____Other, specify_____)

6. (Note to interviewer: Ask this question only if the roof(s) are metal).

   (a) Where were the roof(s) obtained?_____

   (b) How much did they cost?_____KSh.

7. (Note to interviewer: Ask this question only if the roof(s) are thatch).

   (a) Were the roof(s) purchased? Yes No
   (b) If yes, how much did they cost?_____KSh.
   (c) If no, did you gather the materials? Yes No
   (d) If the materials were gathered from the field, how long did it take you?_____man days _____average hours per day

8. (a) Who built the roof(s)? Husband_____Wife_____Children_____ Hired labor_____Others, specify_____
   (b) How long did it take to build the roof(s)?_____man days _____average hours per day
   (c) If hired labor was used, how many shillings did you pay?_____

CRIB OR TRADITIONAL STORE

(Note to interviewer: Check the materials the cribs are made of).

	vertical support	horizontal support	wall	floor
wood poles	_____	_____	____	____
wood planks	_____	_____	____	____
bamboo	_____	_____	____	____
split bamboo	_____	_____	____	____
rock/stone	_____	_____	____	____
hessian cloth	_____	_____	____	____
wire mesh	_____	_____	____	____
woven sticks	_____	_____	____	____
plant stalks	_____	_____	____	____

If walls are plastered with mud, check if muddied:
Inside_____Outside_____Both sides_____

9. (a) Were any of the materials that went into the construction of the crib purchased? Yes No
   (b) If yes, which materials, how much did they cost, and where were they purchased?

Materials	Cost, KSh	Where purchased
_____	_____	_____
_____	_____	_____
_____	_____	_____

   (c) Were any materials gathered? Yes No
   (d) If the materials were gathered from the field, how long did it take you?_____man days_____average hours per day

10. (a) Who built the crib(s)? Husband_____Wife_____
Children_____Hired Labor_____Other, specify_____
   (b) How long did it take to build the crib(s)?
_____man days _____average hours per day
   (c) If hired labor was used, how many shillings did you pay?_____

MAINTENANCE AND RODENT CONTROL

11. (a) Have you done repair work on the crib(s)? Yes No
(Note to interviewer: If the answer to this question is no, proceed directly to question 13).
   (b) If yes, how often are repairs made?_____
   (c) What is repaired?_____
   (d) How long does it generally take?_____man days
_____average hours per day

12. What caused the damage to the store?
Normal wear and tear_____Birds_____
Termites_____Rodents_____Wind_____

13. Have you used any measures to control damage by termites? Yes No

14. (a) Do you use any rodent control measures? Cat_____
Guards_____ Chemical_____
Traps_____ None_____
   (b) If some measures are used, how much did the materials cost?
KSh_____
   (c) Where were they obtained?_____

Section V: USE AND DISPOSAL OF STORED GRAIN

1. For what purposes have you used the grain that you stored from the last harvest? (Note to interviewer: If possible, try to obtain absolute quantities in bags; if no, then proportions of total grain used in percentages).

	Local maize	Hybrid maize	Beans	Sorghum/ Millet
Grain still in storage	_____	_____	_____	_____
Family food consumption	_____	_____	_____	_____
Feeding animals	_____	_____	_____	_____
Beermaking	_____	_____	_____	_____
Sold	_____	_____	_____	_____

	Local maize	Hybrid maize	Beans	Sorghum/ Millet
Gifts	_____	_____	_____	_____
Wages	_____	_____	_____	_____
Repayment of loans	_____	_____	_____	_____
Too spoiled for any use	_____	_____	_____	_____

2. What method do you use for grinding or milling grain for food?
Hand pounded_____Hand grinder_____Animal powered_____
Powered grinder (hammermill/plate)_____
Custom grinding_____None_____

3. (a) Do you generally sort grain before grinding for food? Yes No
(Note to interviewer: If the answer to this question is no, proceed to question 4).
(b) If yes, approximately what proportion of the grain that you removed from the store since the last harvest was too spoiled to use as food?
Local maize_____percent Hybrid maize_____percent
Beans_____percent Sorghum/Millet_____percent
(c) What do you think was the most important cause of this spoilage?
Insects_____Mold_____Rodents_____Other, specify_____
(d) What did you usually do with grain that was too spoiled to eat?
Threw it away_____Animal food_____Beermaking_____
Manure_____Other, specify_____

4. (a) Was any of your grain stolen from your store since the last harvest?
Yes No
(b) If yes, how much? Maize_____bags Beans_____bags
Sorghum/Millet_____bags

5. (Note to interviewer: Ask this question only if some grain was sold from the stores during the year).
(a) About how much was sold? Maize_____bags Beans_____bags
Sorghum/Millet_____bags
(b) Did you have any difficulty selling your grain? Yes No
If yes, please specify why._____
_____
_____
_____

6. (a) Have you bought any grain since the last harvest?
Maize Yes No Beans Yes No Sorghum/Millet Yes No
(Note to interviewer: If the answer to all questions is no, then proceed directly to Section VI).

(b) In what form did you generally buy your maize/sorghum/millet?

	Maize	Sorghum/Millet
Whole grain	_____	_____
Cracked/split	_____	_____
Posho	_____	_____
Sifted maize meal	_____	_____

(c) About how much did you buy? (Note to interviewer: Indicate units).
Maize_____Beans_____Sorghum/Millet_____

(d) Did you have any problems buying grain? Yes No
If yes, please specify why._____
_____
_____

(e) In what month of the year did you buy the most grain?
Maize_____Beans_____Sorghum/Millet_____

(f) What price did you pay in this month of the year?
(Note to interviewer: Indicate units).
Maize_____Beans_____Sorghum/Millet_____

(g) From whom did you buy the largest portion of what you bought?

	Maize	Beans	Sorghum/Millet
Maize board or agent	_____	_____	_____
Cooperative or agent	_____	_____	_____
Local trader	_____	_____	_____
Other farmers	_____	_____	_____
Friends	_____	_____	_____
Other, specify	_____	_____	_____

(h) What was the purpose for which the grain was purchased?

	Maize	Beans	Sorghum/Millet
Family food consumption	_____	_____	_____
Other, specify	_____	_____	_____

Section VI: MISCELLANEOUS QUESTIONS

1. (a) Are you a member of a cooperative society or union? Yes No
(b) If no, why are you not a member?_____
_____
(c) If yes, what are the membership fees?_____
(d) If yes, what services does the cooperative provide?
Buys and sells maize_____, beans_____sorghum/millet
_____Sells farm inputs such as seeds_____
fertilizers_____insecticides_____
grinds/mills grain_____provides credit_____
(e) If yes, what services do you use?
Sell maize_____, beans_____, sorghum/millet_____,
Buy maize_____, beans_____, sorghum/millet_____,
buy seeds_____, fertilizers_____, insecticides_____,
Have grain ground there_____
Borrow money there_____
(f) What services would you like to see the cooperative provide?
_____
_____

2. (a) Have any extension workers visited this farm in the last year? Yes No

(b) If yes, what topics were discussed between the extension workers and you or any other member of your household? (Check).

Crop production_____ Marketing problems_____
Animal production_____ Grain storage_____
Animal diseases_____ Home or family topics_____
Credit (loans)_____ 4K Club work_____
Other, specify_____ _____
_____

3. (a) Have you or any member of your household gone to the office of an extension worker in the last year to ask for assistance? Yes No

(b) If yes, what were the purposes of these visits?_____
_____

4. (a) Would you like more help from extension workers? Yes No

(b) If yes, what help would you like to receive?_____
_____

5. (a) Have you or any member of your household attended any barazas or meetings in the last year where farming was discussed? Yes No

(b) If yes, how many were attended?_____

(c) If yes, how many were sponsored by the Ministry of Agriculture?
_____

6. (a) Have you been to any Farmer Training Centres? Yes No

(b) If yes, to which one(s)_____

(c) If yes, in what way did you feel that your visit(s) were most beneficial?_____
_____

(d) If yes, in what way did you feel that your visit(s) were least beneficial?_____
_____

7. (a) Who in your household, if anyone, listens regularly to a radio?
Husband_____ Wife_____ Children_____ Older members_____
(Note to enumerator: If the answer to this question is no, then proceed to question 8).

(b) Do you own a radio? Yes No

(c) When do you listen most? Morning_____ Midday_____
Evening_____

8. (a) Have you received any credit in the last year from the government or a cooperative union/society? Yes No

(b) If yes, then please specify how much you received and for what purposes?

Source	Amount	Purpose
Government	_____	_____
Cooperative	_____	_____

9. Most of our questions today have been about the handling of your food grain crops after harvest time. There is a possibility that loans might be made available to farmers like yourself in order to repair or build new improved stores, to build or buy on-farm drying facilities, and to purchase dusts and sprays to keep stored grains more free of insects.
   (a) Would you be interested in learning more about improved handling and storage of your food crops? Yes No
   (b) Have you visited any demonstration sites where there were improved storage structures and demonstrations about how to handle and store grain in order to reduce spoilage by molds, rodents, and insects? Yes No
   (c) The proper handling and storage of food grains is important in Kenya so that all that is produced will be available for your household or other people to eat. Do you think that you might be interested some day in improving your stores in order to reduce spoilage of what is stored? Yes No
   (d) If yes, if loans were made available to you, do you think that you would apply for one (check).
   To repair or improve present stores?_____
   To build new stores?_____
   To build or buy on-farm drying facilities?_____
   To purchase dusts and sprays?_____

10. One final question. In the last year, did you sell any grain right after harvest specifically because you knew that if you stored it, it would be too damaged by rodents, insects, or molds before the time came to eat it? Yes No

SAMPLE LABEL

1. District Name_____ Cluster Numbers_____
   Household Numbers_____

2. Kind of Grain_____ Moisture, %_____ Date Collected___/___/___
   Day Month Yr.

3. Type of Storage crib/basket/jar/drum/gourd/box/bag/godown/can/plastic

4. Weight of Sample_____ How Sampled Ear/husked/shelled/pod/unhusked

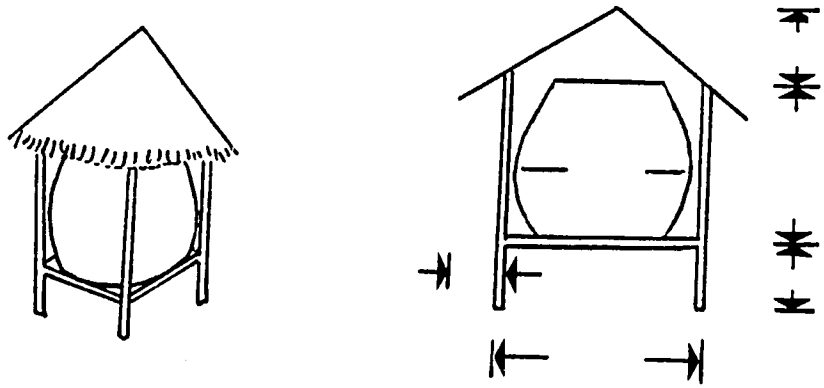
5. Date Harvested_____ Treated_____ Yes No

6. Sampled by TOT/UAA/DEL/CDG

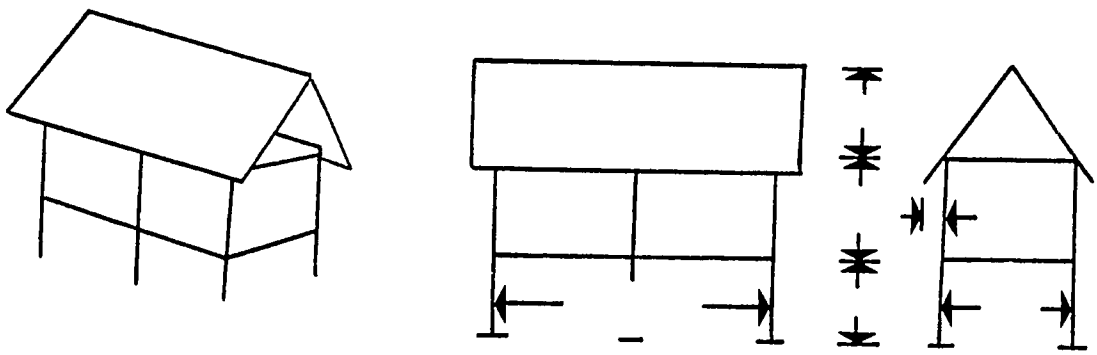
OBSERVATIONS TO BE MADE BY TEAM MEMBERS ON VISTING SMALLHOLDINGS

Name of farmer:_____ Date:_____
Location Number:_____ Ident. Number:_____
Dimension of Store: (All given in centimeters)

1. _____ Traditional store:_____ Not muddied
_____ Muddied: Inside/outside/both sides



2. _____ Rectangular crib:



3. _____ Containers: Jars/box/bags/drums/cans/gourd.
(Encircle appropriate container and sketch)

4. Where are the major stores located?

Isolated farm_____
Small village (less than 30 houses)_____
Medium village (30-59 houses)_____
Large village (more than 60 houses)_____

5. What is the distance from the stores to the:

(a) Nearest house_____meters
(b) Nearest maize field_____meters
(c) Nearest village_____miles _____kilometers
(Fill in one space only)

6. What is the level of technology in the neighborhood?

(a) Indicate approximately what percentage of the house walls are:

Mud/plastered_____percent
Adobe_____percent
Wood_____percent
Grass_____percent
Sun baked brick_____percent
Fired brick_____percent
Other, specify_____percent

(b) Indicate approximately what percentage of the roofs are:

Thatch_____percent
Bamboo_____percent
Sheet metal_____percent
Other, specify_____percent

(c) Indicate approximately what percentage of the floors are:

Mud/Dung_____percent
Dirt_____percent
Elevated_____percent

B. Laboratory Methodology to Determine Loss
Kenya National Crop Storage Study
(Grain Loss Assessment Survey)
Laboratory Analysis Procedure

Note: No. of samples = 534, Weight per sample = 500 gm (approx.)

Step No. I. Sample preparation (For maize and beans)

1. Sieve* the sample to separate dust, dockage and insects from the grain. Hand pick corn cobs, etc. and include as dockage. Weigh dockage, record and dispose properly.

2. Collect dust and insects and seal them in a container for future inspection and identification by entomologist.

3. Weigh clean sample and record.

4. Mix sample thoroughly by coning technique.

5. Divide the sample by quartering technique.

6. Put one quarter in a plastic bag, label with sample code and seal (this will be used for aflatoxin screening).

7. Weigh another quarter and record (this will be used for mold and insect damage analysis).

8. Record moisture content indicated in sample label (if no moisture is given on label, determine moisture with moisture meter and record moisture. Grain from the remaining sub-sample can be used for moisture test).

9. Keep the remaining two-quarters sub-sample for future use.

II. Insect and Mold Damage Analysis

1. Sort moldly broken and insect-damaged kernels and weigh them separately.

2. Count an equal number of sound and damaged kernels, weigh separately and record (if insect damage kernels is more than 50, use 50 kernels only; for less than 50 kernels, use that number for the count).

3. Put the sound kernels back together and coarse crack one quarter for possible hidden insects (treat the insects as in I-2 above and put insects together).

4. Seal back the materials into the original plastic bag, including the container with insects (keep sample for future reference).

---

* Sieve sizes: Top - Slotted (10/64" x 3/4")
Middle - Round (12/64") or other appropriate size
Bottom - Pan

III. Aflatoxin Screening

1. Coarse crack sample from step I-6 above.

2. Examine the sample for BGYF** in a darkened room using the ultra-violet lamp.

3. If negative BGYF is indicated, discard sample. Analysis ends here.

4. If positive BGYF is indicated, proceed in the rapid screening technique of aflatoxin.

5. See attached Holaday Rapid Corn method (P-107) for procedure.

** BGYF = Bright Green Yellow Fluorescence

C. Laboratory Data Sheet

Sample Code_____ Kind of Grain_____
Sample Origin_____
Collected by_____
Analysed by_____ Date:_____

ANALYSIS

A. Grain Quality (Weight given in grams)

1. Grain Moisture, %_____ Sound Grain Wt._____
2. Weight of 1/4 sample_____ (W_S) Broken Wt._____ (W_B) Dockage Wt._____
3. Moldy Kernels Wt._____ (W_{MD}) Total Insect-damaged Wt._____ (W_{ID})
4. Insect-damaged Kernels No._____ Wt._____ (S_{ID}) (50 kernels or less sub-sample)
5. Sound Kernels No._____ Wt._____ (S_U) (Equal number as in 4)

B. Aflatoxin Screening for Maize

1. Black light (U.V. lamp) screening for fluorescent particles.
   _____ positive BGYF _____ negative BGYF
   Remarks_____
2. Myco-column test result for presumptive aflatoxin.
   ____ positive: ____ 2 ppb ____ 10 ppb ____ 20 ppb ____ 30 ppb ____ 40 ppb
   ____ 50 ppb ____ 60 ppb ____ 70 ppb Remarks:_____
   _____

C. Insect Identification in Sample (Job for entomologist)

1. S. zeamais (maize weevil)
2. S. oryzae (rice weevil)
3. S. granarium (granary weevil)
4. R. dominica (lesser grain borer)
5. C. pusillus (flat grain beetle)
6. S. paniceum (drugstore beetle)
7. L. serricorne (cigarette beetle)
8. T. castaneum (red flour beetle)
9. St. cerealella (Angoumois grain moth)
10. P. interpunctella (Indian-meal moth)
11. E. kuehniella (Mediterranean flour moth)
12. C. surinamensis (saw-toothed grain beetle)
13. C. ferrugineus (rust-red flour beetle)
14. T. mauritanicus (cadelle)
15. Tr. granarium (khapra beetle)
16. T. confusum (confused flour beetle)

D. Determination of Weight Loss

I. GIVEN QUANTITIES: (From field sample analyses)

1. W_S = Weight of grain sample (less dockage and dust)
2. W_B = Weight of broken kernels
3. W_{ID} = Weight of insect-damaged kernels
4. W_{MD} = Weight of moldy kernels
5. W_{SK} = Weight of sound kernels
6. S_{ID} = Weight of insect-damaged subsample
7. S_U = Weight of equal number of undamaged subsample
8. W_O = Original undamaged weight of entire grain sample
9. W_U = Calculated weight of sound kernels which became insect-damaged
10. W_{IL} = Weight loss due to insects

II. FORMULATE TO CALCULATE LOSSES

1. Weight loss by insects, W_{IL}

$$W_U = \frac{S_U}{S_{ID}} (W_{ID})$$

$$W_{IL} = W_U - W_{ID} = \frac{S_U}{S_{ID}} (W_{ID}) - W_{ID} = \left[\frac{S_U}{S_{ID}} - 1\right] W_{ID}$$

2. Percent weight loss by insects, % W_{IL}

$$\% W_{IL} = \frac{W_{IL}}{W_O} \times 100 = \frac{W_{IL}}{W_S + W_{IL}} \times 100$$

3. Percent moldy kernels, % W_{MD}

$$\% W_{MD} = \frac{W_{MD}}{W_O} \times 100 = \frac{W_{MD}}{W_S + W_{IL}} \times 100$$

4. Percent broken kernels, % W_B

$$\% W_B = \frac{W_B}{W_O} \times 100 = \frac{W_B}{W_S + W_{IL}} \times 100$$

5. Percent sound kernels, % W_{SK}

$$\% W_{SK} = \frac{W_{SK}}{W_O} \times 100$$

E. Estimation of Insect Weight Loss, by Counting

Quality loss as measured by the personnel at the Laboratory has included in the usable weight two factors of loss which are very difficult to determine. These are: the destruction of the germ which has a high fraction of the protein contained in seed, and second the frass (excreta and rejected fragments) and the dead bodies of insects which remain inside the kernels, both of which are actually unreported weight loss in this case.

A study made in Zambia by the Tropical Products Institute, Slough, England showed a .12 percent weight loss for every 1 percent of damaged grain in shelled maize and weight loss in unhusked maize calculated as .22 x the percent damaged grain + .15% for each week it remained in the store. Thus when shelled maize has 40 percent damaged kernels, as often occurred in our survey, it amounts to a 4.8 percent weight loss.

A correction factor for both husked and unhusked and shelled maize under Kenya conditions needs to be worked out experimentally to account for these types of losses which are measured in the usual ways. C. P. F. De Lima did a study of maize loss in Kenya as a doctoral dissertation entitled, "A Study of the Binomics and Control of Sitophilus zeamais (mots.) Sitotroga cerealella (Oliv.) and Associated Fauna in Stored Maize Under Laboratory and Field Conditions in Kenya," 1978, in which loss as percent was expressed, but further research on field losses at the smallholder farm level is needed under Kenya conditions to establish factors such as those in the T.P.I. study.

F. Aflatoxin Assay Procedure
Holaday Rapid Corn Method*(P-107)

1. Combine 50 grams of ground sample with 100 ml of methanol-water solution. Blend 1 minute at high speed.

2. Filter 15 ml of extract into a culture tube. Add 15 ml of salt solution, cap the tube and shake vigorously for 10 seconds.

3. Filter 15 ml of contents into a second culture tube. Add 3 ml of benzene, cap the tube and shake gently for 10 seconds.

4. Allow the layers to separate. Pipet 1.0 ml of the upper layer onto a #201 Myco-Column. Do not allow the column packing to become dry before adding the elution solvent.

5. When the sample has drained into the Myco-Column packing, add 3.0 ml of elution solvent to the top of the column and allow it to drain.

6. Place the sample column next to a reference column, dim the room lights and shine the ultraviolet light on the columns. A blue fluorescent band should appear about one inch from the bottom of the reference column, at the top of the florisil layer. If a similar band appears at the same location on the sample column, the sample contains presumptive aflatoxin.

NOTES

1. Small separatory funnels may be substituted for the culture tubes.

2. Toluene may be substituted for benzene in Step #3.

3. A small vacuum may be used to drain the columns but the elution solvent should not drain faster than 1 ml per minute.

4. All reagents should be reagent grade. Water should be distilled or deionized.

5. The 20 ppb standard column should not be used to quantitatively accept or reject a sample, since a 20 ppb result could mean the sample contains between 10 and 30 ppb. If <u>any</u> blue fluorescent band is evident on the sample column, the sample should be considered as containing 20 ppb or more aflatoxin and appropriate confirmation analyses should be performed.

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* Reference: C.E. Holaday and J. Lansden, 1975. J. Agric. Food Chem. 23:1134-1136.

6. Standard or reference columns of 10, 20, 30 etc. ppb can be prepared in the laboratory using the #311 Aflatoxin Standard Working Solution.

7. This is the method as approved official first action by the AOAC, October, 1978 using the #201 Myco-Column and the #625 Elution Solvent. The method as published used a different column and a different elution solvent.

8. Methylene chloride may be substituted for chloroform in the elution solvent.

Product Number	REAGENTS
621	Methanol-Water: mix 800 ml methanol with 200 ml water.
622	Salt Solution: dissolve 600 grams sodium chloride, 600 grams zinc acetate and 15 ml glacial acetic acid in 4000 ml water.
623	Benzene
624	Toluene
625	Elution Solvent: mix 900 ml chloroform with 100 ml acetone.
626	Elution Solvent: mix 900 ml methylene chloride with 100 ml acetone.
311	Aflatoxin Standard Working Solution: 14 ng/ml total aflatoxins.
401	Aflatoxin Spiking Solution: 0.5 µg/ml total aflatoxins.

EQUIPMENT

201	Myco-Columns Blender Ultraviolet lamp (365 nm) Culture tubes (20 x 150 mm) Funnel (2.25 inch diameter) Separatory funnel Filter paper	The Myco-Lab Company P.O. Box 321 Chesterfield, MO 63017 Tel: 314-536-1270
751	Myco-Column rack	

APPENDIX CHAPTER IV

A. Potatoes

B. Wheat

C. Rice

D. Screening of Diatomite

E. Species of Insects Found

A. Potatoes

The statement of work of contract No. AID/afr-C-1562, article I Paragraph B, 3 states, "The study team should undertake a field survey of grain storage losses..... as well as other crop storage losses, such as for potatoes." The purpose of this section is to reveal the fact that considerable work has been done and continues with small scale farm potato producers. Therefore, to avoid duplication of effort and waste of expertise time and funds, it was mutually agreed upon by those concerned that this study would exclude loss assessment, etc. of potatoes but would contain some basic reference information that could be useful to any interested persons or agencies.

Mr. George L. T. Hunt of Tropical Products Institute is with Overseas Development Ministry, U.K., and works as the Crop Storage Engineer in the Project Preparation Section of the Kenya Ministry of Agriculture Development Planning Division. He has provided technical and coordination leadership to the problem of reducing storage losses of potatoes. Considerable research by Kenyan and expatriate technicians has been conducted in the past which serves as a basis for an ongoing extension and demonstration program for small scale potato farmers.

Publications relevant to losses and storage of potatoes in Kenya includes the following:

a. Central Bureau of Statistics: Integrated Rural Survey 1974-75, Basic report, Nairobi 1977, p.79 segs.

b. F. Heinrich: Basic Data on the Domestic Horticultural Marketing System in Kenya, Nairobi - Berlin 1975, Table 64.

c. M. M. Shah: Food Demand Projection, Kenya 1975 - 2000, Nairobi 1979, passim.

d. J. Homann, et al: Ware Potato Storage Trial at the Small Scale Farm Level, Final Report to the Government of Kenya on four storage seasons 1977 - 1979, Nairobi/Kenya, June 1979.

e. G. L. T. Hunt: Cheap Potatoes Storage in the Tropics, Ministry of Agriculture, Nairobi, 1979.

f. W. G. Burton, et al: The Potato

g. C. G. Ballestrem and H. J. Haller: Potato Production in Kenya, German Agency for Technical Co-operation Ltd.

h. James E. Bryon: Potato Seed Storage, International Potato Centre.

i. Potato Chitting House, Ministry of Agriculture, Fisheries and Food, United Kingdom.

j. G. Duerr: Studies on the Potato Section in Kenya, Interim Report No. 1-6, Nairobi (International Potato Centre, C.I.P.) June - October 1977.

In summary, research work has already been completed in Kenya in regards to problems associated with storage of potatoes for the small scale producers. At this point, several recommended types of storage facilities and methods are being demonstrated and adopted by the potato farmers and specific varieties of potatoes are being advocated for growing because of their storage facilities. Under these circumstances, no further investigations were made by this study team and no additional recommendations are being advocated.

B. Wheat

Wheat is the second most important cereal grain grown in Kenya. Consumption was about 15 kg. per capita per year in 1977, or about 10 percent of the total food grains consumed. Virtually all the wheat is produced by large-holders and is marketed through official channels. Wheat production has declined in all but two years between 1970 and 1977. Kenya, which used to be a net exporter of wheat, has been a net importer since 1972 according to Statistical Abstract 1978.* This study does not include a report on wheat production because very few smallholders are wheat producers.

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* CBS. 1978 Statistical Abstract.

C. Rice Production in Kenya

Rice production in the country is relatively small in comparison to the production of maize and wheat. The production of rice rests entirely upon the responsibility of the National Irrigation Board, (NIB). Rice is therefore cultivated exclusively in four irrigation schemes in the country. Table A-IV-1 shows the hectarage and total paddy production of Kenya as indicated in a 1977-78 CBS survey.

The production scheme involves the apportionment of a land holding to a tenant by the NIB which in the case of Mwea Irrigation Scheme is 1.5 hectares on the average. The tenants were recruited on the basis of their being landless and not on previous agricultural experiences. Since the establishment of Mwea Irrigation Scheme in 1951 other smaller schemes have also been established which to date totals to a hectarage of 7,577 for the entire country.

Cultivation of the field is entirely mechanized and land preparation is done under flooded conditions. Land preparation and other inputs are provided by the Irrigation board and the costs of which is deducted from the paddy production of the farmer at harvest. An example of the various services and inputs given to a tenant is shown in Table A-IV-2.

Because of efficient control and supervision by NIB in the production aspects at the various rice schemes, it allows NIB to provide collection, drying and storage services to their tenants. Paddy is collected from the tenants immediately after harvest, sun-dried in concrete floors and stored in the scheme's warehouses prior to shipment for milling. All the paddy produced from the rice schemes is processed into milled rice at the Mwea Irrigation Scheme.

The team visited all the rice schemes of the country and came to the conclusion that, except for the usual shattering loss that is incurred at harvest, no serious problem exists in the postharvest handling and storage of rice in the various schemes.

Table A-IV-1: Rice Production 1977-78

Irrigation Schemes	Cultivated Areas		Paddy Production	
Name/Province	Hectares	Percent	Metric Tons	Percent
1. Mwea, Eastern	5,648	74.5	32,289	84.9
2. Ahero, Nyanza	1,369	18.0	3,985	10.47
3. Bunyala, Nyanza	323	4.26	756	1.99
4. West Kano, Nyanza	237	3.12	1,009	2.65
TOTALS	7,577	100.0%	38,039	100.0%

SOURCE: Central Bureau of Statistics, 1978 Statistical Abstract.

Table A-IV-2: Cost of Production for Inputs in 1977-78 Season

			SINDANO KSh	BASMATI KSh
1.	Water Rate		220.00	220.00
2.	Rotavation		60.00	60.00
3.	Fertilizers	(a) Sulphate of Ammonia	58.15	58.15
		(b) Sulphate of Ammonia	58.15	58.15
4.	Seed		24.20	25.35
5.	Vitavax Thirum		NIL	NIL
6.	Spray Nursery and 1 acre holding (.4 ha.)		7.80	7.80
7.	Labor		1.75	1.75
8.	Handling charges	(a) 32 Bags Sindano	100.80	
		(b) 25 Bags Basmati		78.75
9.	Field Boards	(a) 13 1/2" x 6" x 1 (2 pieces)	1.60	1.60
		(b) 12" x 6" x 1 (1 piece)	30.30	30.30
		TOTAL	562.75	541.85

NOTE:

1. No. of tenants during the year was 3,033.
2. Scheme Mean Yield 29.3 Standard Bags of 75 Kg. each.
3. Mean income KSh 8,693.
4. Acreage under crop 13,955 Acres (5,582 hectares).

MWEA Irrigation Settlement

General Information

Total Rice Acreage: As of 30th June, 1978 (5,698 ha.)	14,247 acres
Total No. of tenants	3,106 tenants
Primary Schools within the Settlement	15
Secondary Schools within the Settlement	5
Tenant Village within the Settlement	36
Retail Shops in tenant villages	37
Vegetable; Tea; Charcoal Kiosks	41
Wang'uru main Trading Center	
a. Retail shops	21
b. Bars	10
c. Barber shops	2
d. Carpentry shops	1
e. Open air garages	2
Transport vehicles servicing the Settlement area:	
a. Matatu Taxis	20
b. Buses	7
c. Lorries	
1. Harvesting	80
2. Other times	20

1975-76 Financial Year

Total Manpower Position (staff)

Senior	Junior	Subordinate	Total
12	144	143	299

The Settlement has, since its inception, continued to provide employment for local people on a casual basis. During the last three years an average of 370 people were employed by the Settlement Management every month.

On top of this, tenants employ an average of 3,000 people per month during 3 months of paddy transplanting period and 3,000 people per month during 3 months of harvesting period. In all, the tenants provide employment for 3,000 people for 6 months in every year on casual basis. The settlement therefore has lived to its initial objective of providing both living and employment to the local people.

D. Screening of Diatomite for Possible Insecticidal Properties

Two series of tests were run with diatomaceous earth using the maize weevil as the test insect. Three grades of diatomite and one of pumice were supplied through the courtesy of Mr. R.G. Terry, General Manager and Mr. B.M. Miheso of African Diatomite Industries, Ltd., Gilgil, Kenya. These are processed materials designated as Kensil F., Kensil BU, Kensil S. and Kensil Blue Pumice. All are light weight, very fine powders, variously used as filter packing, insulation or fine abrasives. Some are used as insecticide diluents.

The tests were set up as described on the procedure sheets accompanying this section, with the modification that maize kernels were added in the petri dishes for the second series. The same charge of dusts used in the first series was retained in the dishes for the second series to demonstrate the permanent nature of these products, as has been shown by tests in the United States.

In the first series insects in the pumice and diatomite chambers started dying in 22 hours and all were dead by 94 hours. The weevil in the corn starch and untreated checks showed mortality before 60 hours when 1 insect died in the untreated check. At the end of 454 hours (19 days) the test was terminated and at that time all specimens in the diatomite dishes had been dead for 384 hours (16 days) or 360 hours (14 days), those in the untreated dish for 240 hours (10 days) and those in the check with corn starch had lost only 2.

In the second test the first mortality occurred in 24 hours. All the insects in the diatomite chambers were dead at 142 hours and the test was ended at 300 hours with most of the insects still alive in both checks.

The time of first and total mortality for each of the test dusts is as follows:

Kensil Blue Pumice:	Test 1, 22-70 hrs;	Test 2, 26-142 hrs.
Kensil BU (diatomite):	Test 1, 36-94 hrs;	Test 2, 36- 76 hrs.
Kensil S " :	Test 1, 22-70 hrs;	Test 2, 24- 94 hrs.
Kensil F " :	Test 1, 22-70 hrs;	Test 2, 36-107 hrs.

Check with corn starch: Test 1, 2 insects dead at 195 hours; no more mortality to termination, 454 hours.

Test 2, 1 died at 60 hours, one more at 118 hours, no more mortality to termination, 300 hours.

Check without anything in dish except insects:

Test 1, 1 dead at 60 hours, 3 more by 142 hours, 4 more by 195 hours; all dead at 214 hours.

Test 2, 1 dead at 48 hours, 1 more at 107 hours, 2 more 142 hours, no more mortality to termination, 300 hours.

The results of this screening indicate a probability of usable insect control capabilities in all the earths tested. All the insects which died showed typical dessication symptoms as is characteristic of reports of diatomite and silica aerogel in the literature.

It is strongly recommended that further research on these substances be done, particularly with a goal of developing practical applications for stored grain.

Procedure on Insecticide Candidate Screening

I.	Equipment	Petri dishes, Plastic 85x13 mm
II.	Test Materials	Corn flour (starch), Diatomite S, Diatomite F, Diatomite 80, Pumice (Blue) (All diatomite 2 Pumice grading according to system for Kensil Products of African Diatomite Industries, Ltd.)
III.	Test Organisms	A-Maize weevil (Sitophilus zeamais Motsch.); B-Ants (any of several species of the family Formicidae) (Alternate test organism, to be used in case of inadequate populations of A).
IV.	Procedure	Each replicate will consist of 6 tests:

No. 1 - Check 1: untreated petri dish, Control.

2 - Check 2: petri dish dusted with Corn flour, Control.

3 - Candidate 1: petri dish dusted with Kensil S (Diatomite grades "S").

4 - Candidate 2: petri dish dusted with Kensil F (Diatomite grade "F").

5 - Candidate 3: petri dish dusted with Kensil BU (Diatomite grade "BU").

6 - Candidate 4: petri dish dusted with Kensil Blue Pumice.

Preparation for test: Into each of the petri dishes which will receive dusts put 2 cc of the dust to be tested, replace the lid and hold tightly together while shaking thoroughly to distribute the dust over all the surface inside the dish.

Distribute the residual dust as evenly over the bottom of the dish as possible by holding the dish flat and gently shaking in a horizontal plane. Label the lids with the appropriate test data - date of test, material tested, test organism, temperature at time of introduction of the insects and time of introduction of the insects. Leave space at the bottom of the label sufficient to enter mortality if it occurs and the time of occurrence.

Once all 6 petri dishes are prepared set them along side each other on a table and put 10 test insects into each with as little time difference as possible between the dishes. This can best be done by having six vials readied before hand with ten insects in each. Empty the insects into the dishes as rapidly as possible. Secure the lids on the dishes with tabs of tape or an elastic band. Make observations on the tests every 4 hours, for the first 12 hours, from the time of introduction of the insects into the dishes. At each observation record on the table the number of insects dead, if any, and the time. Always observe closely to be sure whether the insects are dead or just temporarily quiet. Continue observations at 8 hour intervals during daylight for the next week. Record mortality since last observation each time. Terminate the test after the 1 week observation, noting on the label the time and the number of insects still living, noting whether they are normally active or whether they seem reduced in activity.

E. Species of Insects Found

Table A-IV-3: Incidence of Insects by Type of Grain and Province

INSECT NAME		PROVINCE				
Scientific	Common	Central	Eastern	Nyanza	Rift Valley	Western
Acanthoscelides obtectus	common bean beetle	B 1/	B	MB 1/	B	B
Acarus siro	grain mite					S 1/
Anoetidae	mite					M
Anthocoris	bug					M
Braconidae	wasp					
Carpophilus dimidiatus	corn sap beetle			M	MS	M
Chalcidoidea	wasp		M	S	MS	MS
Cryptolestes ferrugineus	rusty grain beetle		M			M
Cryptolestes pusillus	flat grain beetle			S		M
Cryptolestes turcicus	a flat grain beetle		M			MS
Ephestia cautella	tropical warehouse moth					
Ephestia kuehniella	mediterranean flour moth		M	M		M
Lasioderma serricorne	cigarette beetle		S			M
Liposcelis	grain psocid	B	S	S	MS	MS
Lophocateres pusillus	siamnese grain beetle				MS	M
Oryzaephilus surinamensis	sawtooth grain beetle					M
Plodia interpunctella	Indian meal moth					
Reduviidae	bug					M
Rhizopertha dominica	lesser grain borer		S	M	MS	MS
Rodent	rat		MB	MS	M	MBS
Scenopinus	fly					M
Sitophilus zeamais	maize weevil	M	M	MS	MS	MBS
Sitotroga cerealella	angoumois grain moth	MB	MS	MS	MS	MS
Stegobium paniceum	drugstore beetle					M
Tenebroides mauritanicus	cadelle		S	B		MS
Tribolium castaneum	red flour beetle		M	M	MS	MS
Tribolium confusum	confused flour beetle		M		MS	M

1/ M = Maize
B = Beans
S = Sorghum & Millet

APPENDIX CHAPTER VI

A. Addendum to Component A

B. Platform Dryer Illustrations

C. Combination Maize Crib Storage/Dryer Illustrations

D. Bills of Materials

A. Addendum to Component A. Field Testing of New Practices

Introduction:

The Stored Products Protection Laboratory will be used extensively during the second and fifth year of the project, when samples are coming in from the enumerators of the Central Bureau of Statistics. The work load during years three and four will be relatively light. This recommendation proposes that six of the technicians be moved from Nairobi to the field to conduct a detailed field loss survey as outlined below. The head of the laboratory will make periodic trips (perhaps at one to two month intervals) to supervise the field workers.

1. The Establishment of a System to Field Test New Practices

a. Project Description

During the course of the project, and afterward, new ideas for improving grain storage practices should develop from research components of this project or other sources of ideas. Frequently, new technological developments which are developed in a laboratory (controlled condition) setting do not perform as expected in the field. Field testing under normal farm operating conditions can aid in reducing the likelihood of instituting a widespread educational program to promote an impractical idea.

This project proposes to attach one technician to each of six pairs of Bureau of Census clusters. The clusters are proposed because the Bureau of Census has much of the necessary background data on farmers in the cluster and much duplication of effort of data collection would be avoided. Sociological and economic data is available from the data now being collected. It is proposed that adjacent pairs of clusters be selected so the technician can supervise loss data collection from forty families.

A completed detailed description of the methodology for such a project is given in an AID Project Paper entitled, "Reducing Farm Level Post-harvest Grain Losses". Project No. 9311322, January, 1979. Briefly the methodology involves:

1. Select a group of farmers in a small area who will cooperate.

2. Furnish a few of the farmers with commodities or other means to test new practices.

3. Evaluate losses by weighing all grain into and out of storage. The grain would be removed periodically as normally practiced and samples taken when grain is withdrawn for use.

4. The weighing in and out, with appropriate moisture corrections should furnish an accurate value for loss. The samples can be used to determine quality changes and provide some insight into reasons for the loss - mold, insects, etc.

5. The farmers who do not introduce new practices can provide background control data for evaluation of new practices and valuable estimates of regional or national losses.

This project should provide resources to field test approximately 10 new practices during the life of the project with sufficient application to yield a valid statistical analysis.

b. Requirements and Constraints

If six pairs of census clusters were selected as test sites, six technicians will be required in the field. One supervisor should be able to oversee the field technicians on a part-time basis.

Samples would be sent to the central laboratory which is proposed in Section A. The laboratory would have the required personnel and equipment.

This should be a cooperative project involving CBS and the Post-Harvest and Storage Section.

Commodities for testing new practices will be required each year. These should not exceed a cost of about KSh 1000 per cooperating farmer since a larger amount would probably be beyond the ability of average farmers to invest.

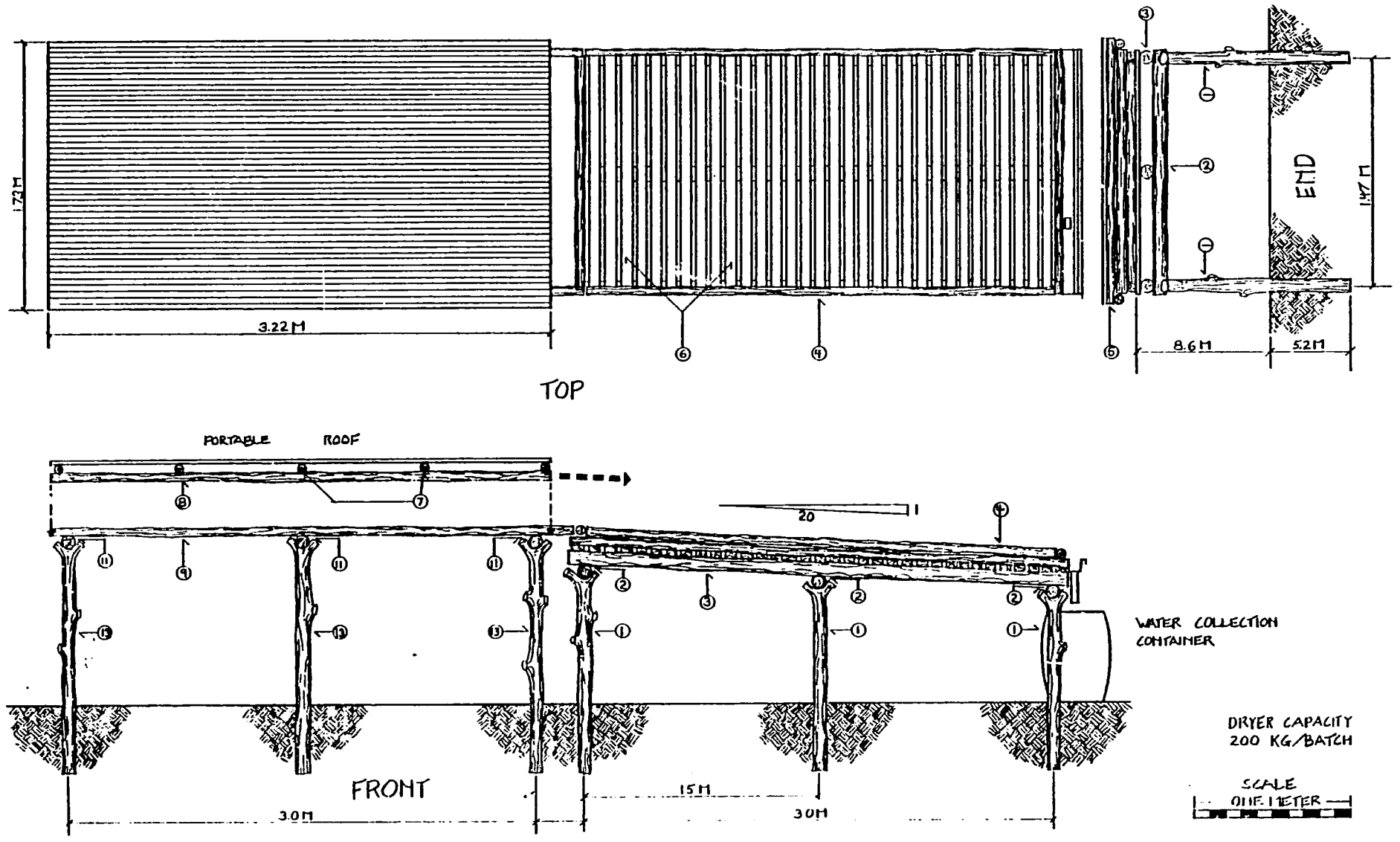
A small amount of equipment would be required for each TA in the field.

Data for project analysis will come from both the central stored products laboratory and CBS. The project analysis and reports should be made by the Post-Harvest and Storage Section.

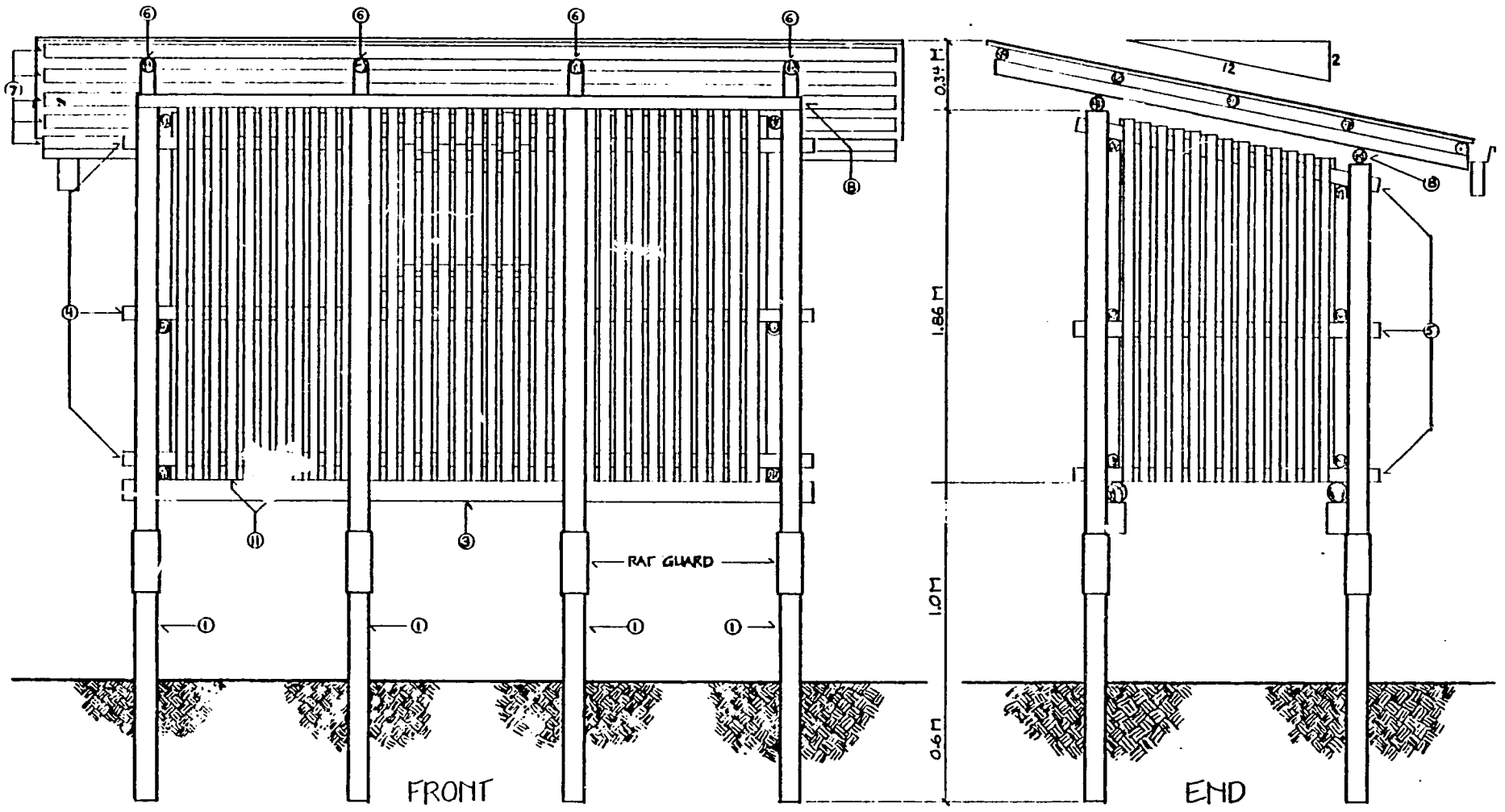
The field activities of the project should be initiated during the third year of the project when laboratory technicians will become available.

c. Elements and Costs for this Project Component

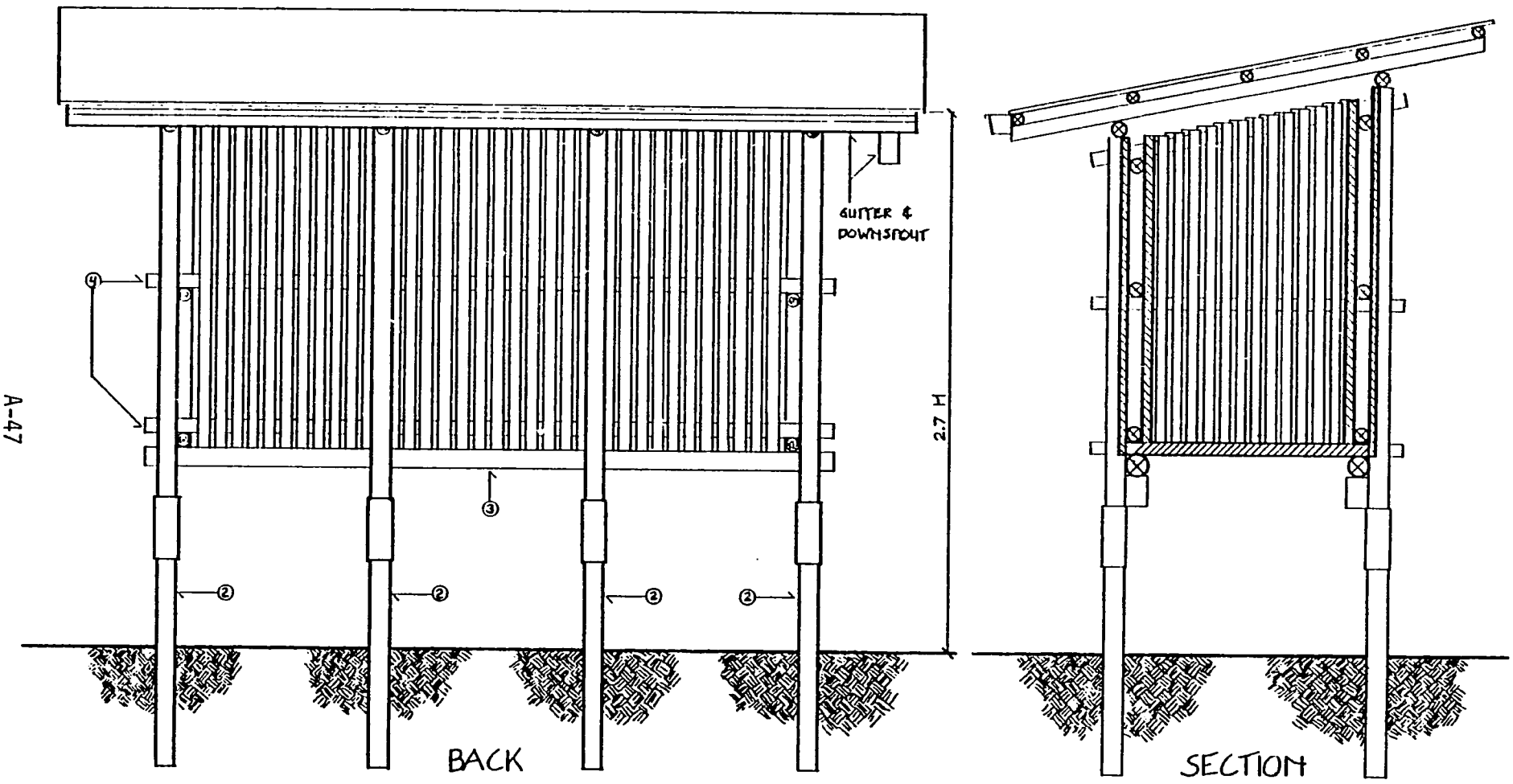
This proposal can be incorporated into Component A at little additional cost. Salaries are already included in the laboratory budget. Moving costs for six technicians will be added. A small amount of weighing and grading equipment will be needed for persons in the field; this should not exceed about $3000. Commodities to be given to cooperating farmers will depend upon the innovations to be tested.



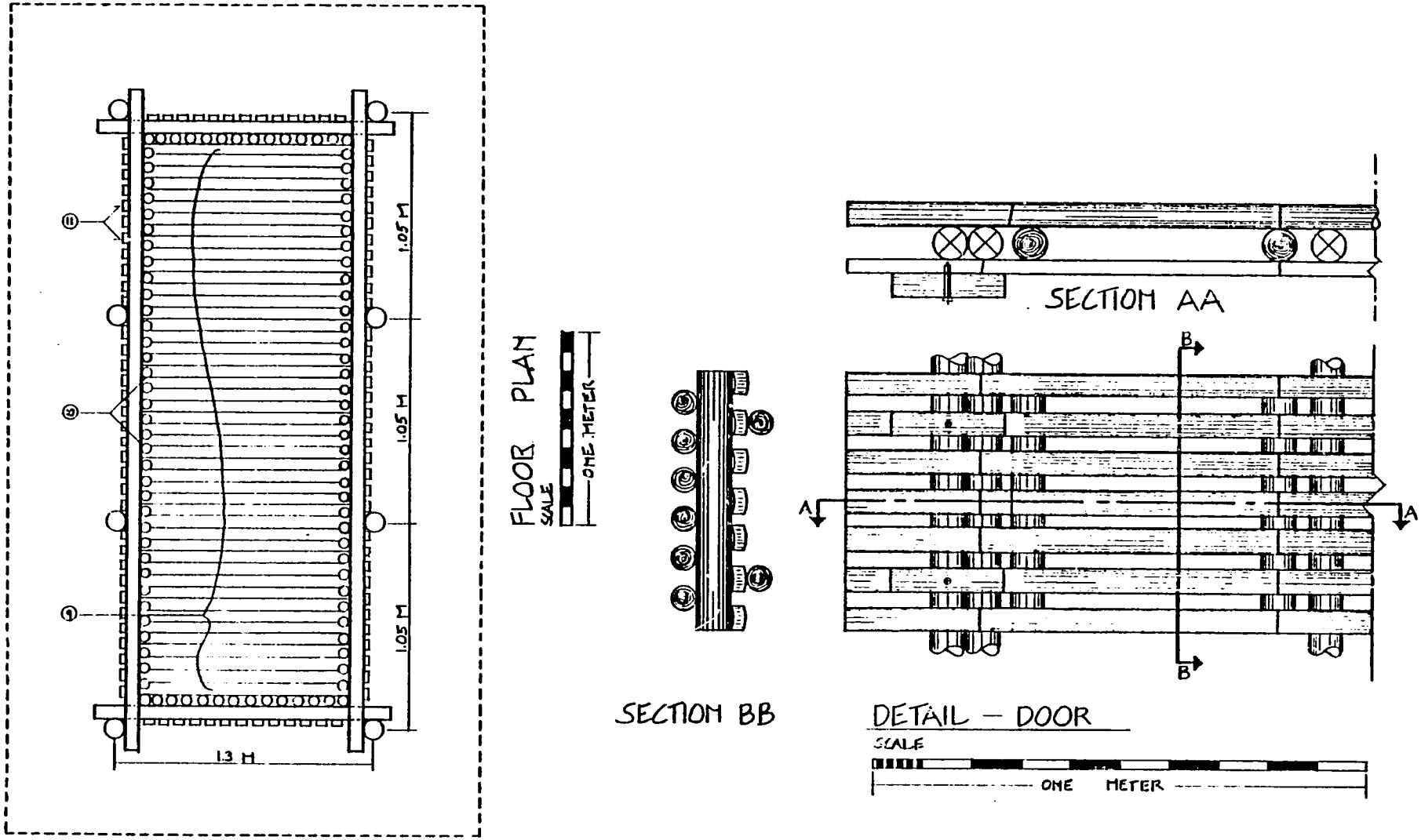
B. Platform dryer



C-1. Combination maize crib storage/dryer



C-2. Combination maize crib storage/dryer



C-3. Combination maize crib storage/dryer

D. Bills of Materials

Table A-VI-1: Bill of Material for a Maize Drying Platform

	Material	Number of Units
1.	Post - 8 cm dia. x 1.3 m	6
2.	Floor Support - 8 cm dia. x 1.6 m	3
3.	Floor Joist - 8 cm dia. x 3.2 m	3
4.	Wall - 5 cm dia. x 3.2 m	4
5.	Wall - 5 cm Dia. x 1.58 m	4
6.	Floor - 5 cm wide bamboo slats x 1.5 m	60
7.	Roof Support - 5 cm dia. x 1.73 m	5
8.	Roof Frame - 6 cm dia. x 3.2 m	2
9.	Top Rail - 6 cm dia. x 3.35 m	3
10.	Nails (for floor) - 2½" (6.5 cm)	50
11.	Rail Stand Cross Support - 8 cm dia. x 1.6 m	3
12.	Nails (for floor support) - 5½" (14 cm)	8
13.	Rail Stand Post - 8 cm dia. x 1.5 m	6
14.	Nails (for floor joist) - 5½ (14 cm)	12
15.	10' x 2' Gal Steel Corr. Roofing	3
16.	Nails (for wall) - 3½" (9 cm)	48
17.	Gutter - 1.6 m long	1
18.	Nails (for bamboo floor) 2½" (6.5 cm)	275
19.	Roof Nails - 2½" (6.5 cm)	60

Table A-VI-2: Bill of Materials for a Maize Crib
(1 m x 1.4 x 3 m)

	Material	Number of Units
1.	Front Posts - 10 cm dia. x 3.45 m	4
2.	Rear Posts - 10 cm dia. x 3.2 m	4
3.	Floor Joists - 10 cm dia. x 3.4 m	2
4.	Horizontal Studs - 7 cm dia x 3.4 m	6
5.	Horizontal Studs - 7 cm dia. x 1.5 m	6
6.	Rafters - 7 cm dia x 2.4 m	4
7.	Purlins - 6 cm dia. x 4.2 m	5
8.	Roof Support - 7 cm dia. x 3.26 m	2
9.	Floor - 6 cm dia. x 1.2 m	47
10.	Inner Wall - 5 cm dia. x 1.8 m	98
11.	Outer Wall - 5 cm wide x 1.85 m Split Bamboo or Sisal Poles	94
12.	Horizontal Outer Wall - 5 cm wide x 3.4 m	8
13.	Corrugated Metal Roof - Gauge 30 x 2.5 m (Or 8' long, gauge 30)	7
14.	Bolts - 5/8" dia. x 10" with 12 washers (or 1.5 cm dia. x 25 cm long)	6
15.	Plain Galvanized Sheet - gauge 30	2
	3 feet x 6 feet (90 cm x 200 cm) (For Rat Guard and Gutter)	
16.	Nails (for studs) - 5 1/2" long (14 cm)	44
17.	Nails (for purlins) - 5" long (12.5 cm)	35
18.	Nails (for rafters) - 5" long (12.5 cm)	14
19.	Nails (for inner wall) - 4" long (10 cm)	390
20.	Nails (for outer wall) - 3" long (7.5 cm)	422
21.	Nails (for floor) - 4 1/2" long (11.5 cm)	94
22.	Roof Nails (for roof) - 21/2" G.I. Nail (6.5 cm)	180