E V A L U A T I O N

ON-FARM GRAIN STORAGE PROJECT
PROJECT NO. 615-0190

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EXECUTIVE SUMMARY

The On-Farm Grain Storage Project has created an awareness of post maturity losses in maize and demonstrated methods to reduce those loss levels. The increased awareness is evident among extension staff and farmers. An economic analysis of the proposed improved methods shows a very favorable economic return for farmers and, if the project is expanded, for the entire country. This analysis underestimates the return because it doesn't include credit for significant quality improvements. Assignment of an economic value to these is difficult.

Observations and Conclusions.

The Project Design defined the problem and a logical program was outlined not only to solve the specific problem, but also to strengthen supporting institutions (particularly higher education and extension). Subsequently the project was compressed in time, personnel and contract expenditures.

Although most extension and laboratory personnel are paid by MOA, about 50% of the contract budget is for personnel support. Many people have suggested that a higher percentage should have been devoted to training, support equipment and facilities.

Most of the first two project years was devoted to development work with the major extension program scheduled for the last two years. If the project is terminated after three years, support for several important activities (cribs, platforms, bicycles, and motorcycles) will be much lower than budgeted. In some Divisions the extension post harvest programs have not developed well enough to be expected to continue without further support. Plans for the fourth year are expected, if the project is continued, to correct these deficiencies.

Project Performance

Observations and Conclusions.

The list of project accomplishments is impressive. It has created an awareness of post harvest losses. The improved harvest and storage recommendations are recognized by farmers to improve grain quality and decrease labor requirements as well as reducing losses of grain weight. The training efforts have been well focused and successful. They generated motivation as well as imparting knowledge. The laboratory facility at Maseno can be a useful extension support facility.

Contract expenditures are well below the expected level (42% of total budget on 31 January 1986) largely because of cancellations and purchase delays. Based on project plans for 1987, we estimate that about 60% of the budget will be expended by the end of the fourth year.

Over 70% of the trained personnel have or will return to their previous positions, but MOA must make continued service attractive. Otherwise the trained people will be attracted to positions outside the Ministry. Not all people selected for training were in post harvest work.

Adoption rates for the improved storage management recommendations can not be estimated yet. However, based on storage insecticide sales, it is evident that the treatment recommendation is being rapidly adopted.

The cribs or raised basket drying and storage structures have been awkward in several respects. They are the most visible evidence of a demonstration and therefore are seen as an essential element. Project personnel have tried to counter this perception

and to de-emphasize the structures. Nearly half of the loss reduction can be realized by adopting the improved management practices that do not require an improved structure (the only capital intensive element). This has been partially successful because the shelling and treatment recommendations have been adopted by many farmers who have not built improved structures. The improved structures were the primary element in the grain storage management plan that required testing and thus the major extension effort might have started earlier if the early harvest/drying had not initially been included. Finally the facilities for drying and storage are the part of the program that is most sensitive to farm size, social conditions and climate. Thus numerous structure options are needed (designed and tested) and the extension staff must be able to recommend the most appropriate options for each farmer.

Extension staff (from District through sub-location levels) are seriously handicapped by lack of adequate transportation.

Recommendations.

The original plan recommended that the laboratory be used as a regional grain monitoring unit. This is valuable only if it is part of a national effort. We believe that converting the laboratory to a regional (western Kenya) extension investigation center is a better option. Such a facility should have a manager who administratively is responsible to a Steering Committee composed of the three PDA's and representatives of LBDA, ICIPE, KARI and the MOA Information Center thereby assuring that the center serves the entire region and interfaces with related activities. Other professional staff should include a communications specialist, a soil chemist, an entomologist (or a pest management specialist) a microbiologist/micologist and an

agricultural engineer. The facility's role should include providing investigation/demonstration facilities for extension specialists, providing technical support such as soil tests, insect and disease identification and minor design assistance; and undertaking testing or proof of concept work based on research results and appropriate for extension in the region.

The Program Manager/counterpart of the CPC, should answer to the Provincial Directors of Agriculture. We believe that people should identify with the program being developed rather than the project. Therefore we recommend that the project have administrative office(s) close to the PDAs' office(s) and if possible share common stationery, telephone numbers, and addresses. Furthermore when the project termination approaches, project personnel should gradually shift from their motivational, enthusiastic, highly visible role to one that is much more invisible by working through the counterparts.

If the project is continued for another year, it is important to find people for the vacant project positions and to direct increased attention to the transportation issue. Purchasing the bicycles and motorcycles will help, but even in the Districts where motor vehicles were provided, there are continuing transportation problems. Perhaps more vehicle maintenance and operating funds need to be channeled into District budgets.

The MOA must find ways to make continued service attractive and to reward outstanding performance. When training opportunities exist, priority should be given to people already in the program. There should be greater opportunity for people (who are giving exceptional performance and have demonstrated the ability to do higher level jobs) to be promoted or otherwise rewarded. We did not review staff salaries, but these need to be competitive with those paid people with similar abilities in non-MOA positions.

Expanded Project

Observations and Conclusions.

Grain (maize) losses appear to be high throughout the country. In most maize growing areas, improved post harvest practices can be economically attractive.

Opportunities may exist with other food crops but this is not clear from existing reports. Very high sorghum loss rates have been reported and questioned. Post harvest bean losses are reportedly low, but the estimate did not include quality losses which can be very high due to hard-to-cook changes. Potatoe losses are probably high, but we are not aware of a comprehensive study.

Recommendations.

There is little doubt that the improved post harvest management recommendations can be very beneficial - economically, nutritionally and in terms of food quality. The adoption rate for these recommendations is still unknown. We can not recommend initiation of an expanded project until there is more adoption evidence. In the interim, extension efforts in Western and Nyanza should be intensified as recommended before.

As soon as adoption rates can be projected to justify expansion, the training and extension efforts should move into regions with similar climate, agriculture and social conditions. Simultaneously, studies and tests necessary to facilitate similar efforts in other maize growing regions should be initiated. This phased movement - study and test recommendations in one region

while training and facilitating intensive extension efforts in the previous region - will make it easier for educational institutions to provide the required training and should minimize the testing necessary before extension efforts can begin in a new region.

There is a parallel maize storage program under SIDA and located in the Rift Valley. While this project originally focused on farm structures and was dominated by structural engineers, it has now adopted a program almost identical to that of the On-Farm Grain Storage Project (OFGSP). The SIDA project plans to expand its geographic scope substantially in 1987-88. The SIDA project continues to have greatest strength in structural design while the OFGSP has its greatest strengths in extension and the potential for extension support through the laboratory. Both efforts lack storage engineering and farm management expertise. We recommend that the two projects be closely coordinated to avoid duplication of effort and to meet critical needs most economically.

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INTRODUCTION

Background

Agriculture is important in Kenya. The country is only marginally self sufficient in food grains. The population growth rate remains very high - about 4.1% a year. Agricultural production growth has averaged less than three percent per year since 1972 with the exception of the last two years which had very favorable weather conditions. Periodic poor crop years have led to large scale food imports and increased foreign exchange shortages. Agriculture contributes one third of the gross domestic product and maize is the most important product.

Approximately ninety percent of the maize is grown by smallholders - farmers with less than twenty hectares. Among this group, only three percent have more than eight hectares. Poor smallholders have average holdings of 2.1 hectares. This (with the further restriction of less than 22 bags of grain production annually) was the target group in Western and Nyanza Provinces for the On-Farm Grain Storage Project (the Project). The purpose was to increase the use of more effective on-farm grain drying and storage practices in Kenya. Preliminary post maturity loss estimates for maize suggested that losses could be reduced by eleven percent - the equivalent of a thirteen percent production increase with existing technology.

This evaluation is of the project three years after its start. The first project personnel arrived in February 1984. Early activities focused on project establishment. This was followed by a testing and limited demonstration phase during which the proposed technological solutions were tested in the project region and the social structure was studied to identify and test

appropriate extension education methods. Simultaneously key personnel were being trained. Extension efforts (the primary project activity) became the dominant effort in 1986.

The Current Project Status

Clearly the Project is having a significant positive impact on grain storage practices in western Kenya. The number of people that have received training or extension assistance on grain storage exceeds 7,000. Over 300 farm demonstration sites have been selected for assistance. Improved post maturity practices have been taught and facilities and supplies have been made available to each. There is no doubt that grain harvested, dried and stored following the improved practices has much lower loss rates, can be held for longer storage intervals and has superior organoleptic qualities. The field day concept introduced into the T & V system is popular and effective. Grain storage insecticide sales have increased and some farmers are building improved storage facilities without direct project assistance.

At the same time, the project is not the project that was originally planned. The project resource expenditures have been substantially reduced by numerous delays, non-approvals and reduced staffing. Most of these changes were external to the project and thus must be considered to be design changes frequently occuring after the planned implementation.

Selected Concepts

The grain losses addressed by the Project are referred to by various terminologies storage losses, post harvest losses and post physiological maturity losses. We understand the technical project scope to be best defined by the latter terminology. Unless a modifier is used, losses in this report refer to post physiological maturity losses.

The Project plan focused on extension education with supporting staff training and modest testing/demonstration work. Frequently the tests or trials were incorrectly called research. This work was not intended to identify new solutions to a problem or to generate original ideas. Rather it was designed to demonstrate the applicability of existing grain storage technology to the problems in western Kenya. Therefore the original terminology, "tests or trials", is more accurate than "research".

The distinction between and need for both training (education) and experience (expertise) is important. A person does not become an expert through education alone, but also must include experience with other experts in the field. To be sure, either training or experience can partially substitute for the other, but both are essential. The Project plan wisely included post-training (education) experience with experts on site. Unfortunately the project schedule changes will preclude the counterpart experience phase for the six M.S. students.

Within the discipline of engineering or even agricultural engineering there are numerous specializations. To be sure, all engineers graduating from Accreditation Board for Engineering and Technology (ABET) accredited schools have a common background in mathematics, physical and engineering sciences and liberal arts. But each person specializes through the appropriate selection of additional engineering science and design courses and experience after graduation. The complexities of each speciality or subdiscipline are such that a person can not transfer between them without additional education and experience.

An agricultural engineer that has specialized in structures will have many courses in statics, strength of materials, structural material properties, soil bearing strength, agricultural structures, fasteners and environmental control. One that has

specialized in processing or grain storage will be well versed in physical chemistry, reaction kinetics, process design and scale-up, materials and reactions, heat and mass transfer, drying, processing, agricultural products and chemistry (organic and food). The expertise of both are needed in a grain storage project because the cribs must be structurally sound, and the entire grain handling system (from maturity to consumption) must be designed to provide a quality product.

This distinction seemed not to be understood by several people interviewed and the writer of one report we reviewed." The writer referenced the need for a grain storage engineer and then added, "..... local diploma holder with specialization in Agricultural Engineering .... candidates could be drawn readily from places like the Machinery Testing Unit, Provincial Irrigation Unit or..." Such persons could not solve grain drying and storage problems. Similar things can be said about specialists in other disciplines.

Grain losses include not only loss of weight, but also loss of quality. Frequently the loss concept focuses only on the former until the quality becomes so poor that people reject the grain as food. In reality, quality losses (nutritional, organoleptic and health/safety) are as important as weight losses, but harder to economically evaluate. This is important for the Project because grain, we observed, that had been stored with the improved management practices not only had reduced weight loss rates, but also retained much higher quality.

An evaluation report is usually based on a review of existing documents, interviews with knowledgeable people and very limited observations. Based on evaluation team members expertise, conclusions are drawn and recommendations identified. Significant components of this evaluation were forced to take a modified

approach. Because of the unfilled positions, many documents and other basic information sources in these areas are not available. Evaluation team members attempted to quickly calculate or estimate the results that should have been available had the positions been filled, but obviously the confidence level is reduced.

Report Organization

The Evaluation team assignment (ANNEX A) requested evaluations of three major areas: project design, particularly in light of the implementation revisions; progress toward achieving the project outputs including an assessment of project impact; and the feasibility and possible mechanisms for an expanded On-Farm Grain Storage Project. This report includes a chapter on each evaluation area. Relevant conclusions and recommendations are included with each chapter.

ANALYSIS OF THE PROJECT DESIGN

Purpose and Design

The project purpose was, "To increase the use of more effective on-farm grain drying and storage practices in Kenya." To accomplish this, the project was to devise, implement and extend innovations of on-farm grain storage to small farm holders in the Nyanza and Western Provinces using the following strategy:

1) Test and adapt existing on-farm grain drying and storage technology to local conditions through extensive participation of farmers in the identification of acceptable practices and through controlled testing on smallholder farms.

2) Develop proven technological packages (practices, materials, equipment and structures) for appropriate micro-ecological areas and widely demonstrate these packages in smallholder fields on a subsidized basis.

3) To insure the spread and maintenance of the benefits gained.

   a. Refine and strengthen effective methodologies to promote the widespread use of suitable technological packages among western Kenya's smallholders.

   b. Enhance the capability of the Ministry of Agriculture to monitor, evaluate, and expand this initial project.

   c. Increase the capability of agriculture educational institutions to teach grain drying and storage.

The project beneficiaries were to include:

1) The smallholder farm families who produce less than 22 bags of grain annually. These families tend to be among the poorest of the region and face many constraints which inhibit them from adopting the optional technologies to reduce grain losses. They should have benefited from reduced on-farm losses and food contamination.

2) A second category of beneficiaries were those who become part of the field testing, demonstration, and extension systems developed and strengthened as a part of this project.

3) Others benefiting from the project are those citizens throughout the region:

   a. from increased availability and quality of food stuff including improved nutrition, food taste and safety.

   b. from GOK savings resulting from the reduction of necessary purchasing, handling and transporting of domestic or imported food grain into western Kenya.

To accomplish these goals, the project was to supplement the existing, T & V extension personnel and the new post harvest officers with:

Personnel Positions	Period of Contract
Grain Drying and Storage Engineer (Project Coordinator)	4 years
Mycology/Entomology	3 years

Extension/Non-formal Education	3 years
Sociology/Economics	2 years
Extension Specialist (2)	6 years
Short term technical consultants	64 months

Originally the first year was to be devoted primarily to project establishment, identification of people, foreign training and testing of the technology. Team member arrivals were phased with the last people, the extension specialist, arriving late in the year. In the second year, testing was to continue and extension planning was to be undertaken. The MSc degree students were to start in year one and continue into year three. Short term foreign training was to occur early in year two. Extension was to be the primary effort in years three and four. Continued testing or adopting of existing technology for unique social, agricultural or ecological problems was to continue in years three and four. The economic assessments were to be completed late in the third year.

Increasing the capability of agricultural education institutions to provide on-farm grain drying and storage technology was to overlay other activities in the first few years. After the testing was largely completed, the laboratory (Grain monitoring Unit) was to be given to the Ministry of Planning/Central Bureau of Statistics to monitor farm stored grain. Finally the Project Coordinator/Team Leader was to prepare a report regarding expansion of the effort to a nationwide basis.

Design Changes

Design or implementation changes have been drastic and usually as a result of delays or non-approvals, not the outcome of revised comprehensive planning.

1) Sixty or (26%) of the planned 231 person-months of long term consultants have been cancelled. This has eliminated the Farm Management/Economist activities, reduced the Grain Storage Entomologist/Biologist time by one third and cut the Grain Storage Engineer time by one half. These reductions caused cancellation of critical project activities. They also made some desirable options (for example alternative dryers and use of local materials for storage structures) difficult, if not impossible.

2) Of the planned 64 person-months of short term technical consultants, only five (8%) have been used. Note this does not include short term extension (0% used) and evaluation (27% used by April 1987).

3) After three years of the original four year project, only 42% of the contract money has been spent. Neither the original project plan nor current plans project a significantly increased spending rate in the fourth year if it is included.

4) The project plan was for grain, but only maize (the most important crop, but not the grain with the highest estimated percent losses) has been considered.

5) Most of the expatriate staff arrived simultaneously instead of in the carefully planned phased pattern. As a result specialists diverted their early efforts until the project needed their speciality and then had less time to complete their assignments. This also gave the project a high profile very quickly thus creating impossible expectations.

6) In-country staff were consistantly identified late. At times this made temporary staffing and training

necessary. In other instances it created extra work to process required papers. For some people (most notably the M.S. students) the delay reduced or eliminated the planned counterpart experience - which is essential if the full benefits are to be realized after the formal project completion.

7) The third year contract was approved a month after the previous contract had expired. This decreased the lead time for extension/demonstration efforts prior to harvest. It also precluded the use of local materials in the on-farm demonstration structures. To avoid delays and interruptions, approvals are needed well before the contract expiration

8) None of the ten planned M.S. research grants have been given to students at the University of Nairobi. While this idea sounds good, it may have not been feasible from the beginning.

9) None of the bicycles (700 planned) or motorcycles (50 planned) have been ordered. The plan included these to enhance the mobility of extension personnel when the extension phase began. Transportation is consistantly identified as one of the most serious constraints for the program.

10) The mid project evaluation is occurring ten months late.

Observations and Conclusions

The original design was good. It identified an opportunity (improved on-farm grain storage) and outlined a project to find solutions, to establish a related continuing program, to strengthen supporting institutions and to develop a plan for program expansion.

The project Coordinator was located at the Maseno laboratory. This was logical since the Coordinator also had technical responsibilities at that location. However, this decision had several negative results. The laboratory is a component in the continuing program - not the central focus nor the administrative center (which we feel is the PDAs' offices). Furthermore, this and the significant control retained by MOA, Nairobi, separated the project management and activity from the Provincial personnel, who if involved, could have given more enthusiastic support.

Alternative project staffing can be hypothesized. For example the CPC ideally would not have had technical responsibilities. Short term consultants might have fulfilled some responsibilities. We did not identify an alternative staffing pattern (short of adding and additional person) that solved more problems than it created.

Perhaps one or more expatriate positions could have been filled by a Kenyan. That is economically and functionally desirable, but no in-country person was identified for the unfilled social economist position. This appears to be one of the more likely positions for a Kenyan.

Inadequate resource support (transportation, operating budgets, teaching materials, salaries and other incentives) seriously limits extension staff productivity. From this view and with the knowledge that the MOA was responsible for all Kenyan extension personnel salaries, it is surprising that half of the project budget was allocated to personnel (ANNEX D).

One year of intensive extension efforts on a new topic (grain drying and storage) with substantial external assistance is not sufficient to create a program and assure its viability. If the possibility of a three year project was realized sufficiently early, an early extension start should have been considered. Perhaps the shell and treatment ideas could have been extended

earlier than the full package since the primary testing needs were for the drying and storage facilities. The near simultaneous arrival of all but one of the team members created an early high project visibility without the ability to deliver the primary output - the extension program.

Recommendations

1) The current project should be continued for a fourth year as originally planned.

   - The primary focus should be on continued intensive extension. The transportation problems experienced by FES, LEO's, DEO's DAO's should be addressed. The bicycle and motorcycle programs should not be delayed any further. These were needed last year. More demonstration farms should be established and the kit grant program should be initiated. Staff training should continue.

   - The baseline survey and economic studies should be completed.

2) The Project Contractor must have the flexibility to fill essential project positions. When adequately qualified Kenyans in the extension program are available, they should be given priority. If they are not available, other qualified Kenyans, short term consultants and long term consultants should be considered in that order.

3) More local program control is needed. We recommend giving as much authority and responsibility to the PDA's as possible. Local people should be involved in the program planning. This should give them more incentive to support and have personal interest in the program. The Project Manager should be answerable to the PDA's of the involved provinces.

PROGRESS TOWARD ATTAINING EXISTING PROJECT OBJECTIVES

Desired Outputs

The original project outputs include:

a) Creation within the Ministry of Agriculture (MOA) the capacity to stimulate interest and participation of smallholders in identifying grain drying and storage problems; to organize the field trials necessary to test and adapt technology to local conditions; and to conduct demonstrations of that technology. (The Field Testing and Demonstration Unit - FTDU).

b) Improved MOA capacity to facilitate adoption of appropriate on-farm grain drying and storage technological packages by smallholders. (Post-harvest Storage Branch and Extension Service - Extension).

c) Increased capability of agriculture educational institutions to provide training in on-farm grain drying and storage technology. (Embu, Bukura, Egerton and University of Nairobi - Education).

d) Creation of a Ministry of Planning/Central Bureau of Statistics (MOP/CBS) Unit to monitor and evaluate stored grain losses. (The Grain Monitoring Unit - GMU).

e) Written reports and recommendations regarding the need for financial assistance to smallholders to support grain drying and storage activities and the most effective delivery systems. (Financial Assistance).

f) Written report of the Contract Project Team Leader regarding how best to expand this initial regional effort on a nationwide basis. (CPC expansion Report).

Progress

FTDU

The Ministry of Agriculture has shown their interest by actively participating in on-farm grain drying and storage extension work among smallholder farmers. Following the initial test period, MOA staff have organized field days at all demonstration sites (see Annex F), have built demonstration structures at different showgrounds and have availed their staff to training activities related to post harvest drying and storage. The Ministry has also committed substantial funds to post-harvest activities (1985 $31,569; 1986 - $45,049; and 1987; $236,986); this is in addition to the KPounds 76,382 committed to staff salaries. To be sure, these activities have been heavily supported by Project personnel, equipment and financing, but an independent MOA capability is developing.

The project has organized, conducted and evaluated tests of existing on-farm grain drying and storage technological packages. Based on our assessment (Annex E) the losses incurred with the improved technology are only slightly over five percent. This compares with the near sixteen percent reported for traditional storage systems.

Extension

In order to facilitate adoption, the Ministry of Agriculture has posted staff at the Provincial, District and Divisional levels who are directly involved in post harvest drying and storage. Twelve

of these staff were among the nineteen persons sent to TDRI for special training in 1985, six are presently studying for M.S degrees in the USA and five senior officers of the Ministry have had special training tour in the USA related to the activity (Annex F). In addition intensified educational work among farmers fundis, T.A.s and T.Os has been realized and are (with project support) to be continued in 1987.

Education

The training of extension workers in on-farm grain drying and storage has not been emphasized by the training institutions in the past. However, staff from Embu and Bukura Institutes (Annex F) participated at the 9 week training at TDRI and are expected to incorporate those topics in their training programs. Books and some laboratory equipment have been donated to these Institutes and to the Egerton University College. Already, these institutes have some grain storage structures for training. This effort must however continue to be stressed.

GMU

To facilitate the testing phase of this project, a Grain Monitoring Unit (laboratory or GMU) was built, equipped and staffed at Maseno. Following this project phase, the original design envisioned the laboratory being transferred to the Ministry of Planning/Central Bureau of Statistics to monitor on-farm stored grain in western Kenya. The laboratory effectively served the project testing needs.

At present, the laboratory is continuing to evaluate submitted samples, but several problems are evident:

a) There is an eight week backlog of samples waiting to be tested for aflatoxin. This is because they are using both the screening and confirmation tests on all samples.

b) The results are being stored in a computer, but have not been analysed for the last year and the results are not being reported.

c) The labor requirements for several tests being run is very high. For routine monitoring, some of the tests need to be changed.

d) While the current technicians seem to be competent, the absence of a highly qualified technical manager is a concern. It is doubtful that the lab will adopt new techniques as that is appropriate and it is possible that collaborations and reproducability with other laboratories will decline without such leadership.

e) No nutritional tests are being run. The laboratory is equipped to determine total nitrogen in a sample and thus infer protein content. However, the test is time consuming and has not been used.

We considered three possible roles for the laboratory:

a) Become a regional grain monitoring laboratory as originally envisioned in the Project Paper. Adminstratively this could be under MOA or CBS.

b) Become a research facility administratively under KARI. As such, we would hope that it continued to work on post maturity grain handling and storage and that the work included testing or proof-of-concept work for the region.

c) Become an extension investigation center for the western region.

Certainly non-laboratory options exist for the facility and these should be considered.

Financial Assistance

Because the economist/farm management specialist was not identified, nothing has been done on this requested output. In a subsequent section the Economist on the Evaluation Team has reported preliminary information, but this needs refinement. The absence of this component is considered to be serious.

CPC Expansion Report

This is not due yet, but we understand that it is in preparation.

Related Issues - Personnel Training

A summary of the grain storage training to date is in Annex F. Of the 19 people trained at TDRI 15 are still on jobs relevant to post harvest on-farm grain storage. This reflects 21% lost in about 2 years even though some of the staff are still working within GOK services.

Five Kenyans selected from key positions in MOA and the two western provinces, Nyanza and Western, received two months training in grain storage and marketing at Kansas State University (USA) to increase their knowledge base of on-farm grain storage losses.

The trained personnel presently working at the field level estimated they use about 50% of the knowledge they gained during training. Those already with relevant agricultural training (prior to the TDRI course) feel that the training reinforced their knowledge without adding any new substantial knowledge. Generally they feel competent and effective in their present level of work. Generally the training needs to be augmented with relevant, in-country experience - preferably with a mentor.

Information assembled by the on farm grain storage extension specialists followed closely the findings from the trials of the first two years of the project. Teaching aids, pamphlets, posters and slides were well designed. The technological packages were presented during the production season through the T&V extension system.

Six agriculture officers were selected to receive training toward masters degrees at USA universities. Three enrolled at the University of Georgia studying Microbiology, Agriculture Economics

and Agriculture Engineering. Three enrolled at Mississippi State University to study Extension Education. Their return is not expected until December 1987. Their late start and hence return does not allow for the extended work with their counterparts. Without practical application of their knowledge of on-farm grain storage in Kenya, and counterpart interaction, their initial effectiveness will be reduced.

The ten technicians and one chemist at the laboratory were trained by the expatriate Mycologist/Entomologist and are performing their duties as they were trained. The reduced time of the expatriate and absence of continued technical leadership has reduced the effectiveness of the technicians in performing their assigned duties.

Integration

Postharvest activities have been integrated in the National Extension Project and FES cover post harvest activities as part of their regular activities whenever appropriate. Many farmers in the area under review have attended field days and demonstration (i.e. 3000 farmers in Western and 3600 in Nyanza, See Annex F).

Economical Analysis

There are three clearly identifiable structures recommended by the program.

a) The raised platform basket uses a basket that is slightly larger than the traditional basket. The basket cost is KShs 200-250. All materials and labor are purchased. The storage capacity is twelve bags (ninety kilos per bag) of shelled maize.

b) The two section crib does not use a basket. All construction materials and labor are purchased. The storage capacity is 25 bags of shelled maize.

c) The improved traditional basket is raised and protected from rodents. Local materials are used when possible including a new traditional basket which costs KSh 50-80. The average capacity is eight bags of shelled maize.

The construction costs for each structure were obtained from the Project employee responsible for procurement of constructrution material. The evaluation team also conducted a quick survey of alternative construction costs. The costs vary depending on whether the farmer uses purchased materials including labor or uses materials obtainable in the immediate neighborhood. The cost of constructing a new raised basket was estimated at KSh 1020.60 ($ 63.79) while for the two section crib the cost was KSh 1638.75 ($ 102.42). The improved traditional basket only costs KSh 500 ($31.25).

On the other hand, if a farmer uses local materials obtainable from the immediate neighborhood the cost of constructing the crib ranges from KShs 240 ($15.00) to 500 ($31.25) per structure. Capital outlays of KShs 1000 ($62.50) or more may be prohibitive to most poor farmers while they may afford one-fourth to one half of that amount. There is a need to investigate the use of local materials at the farm level, to reduce construction costs.

The economic gains obtained from the project are: (a) increased farmer income as a result of reduced grain weight losses; (b) increased grain quality due to reduced levels of aflatoxin and other types of contamination; (c) reduced labor for maize drying, (d) increased farmer's income by selling high quality grain in the local markets when the prices are high; (e) increased household food security; and at national level, (f) saving of resources and

possibly improved foreign exchange if the saved grains results in decreased imports or increased exports.

An attempt has been made to quantify increases in farmers incomes and total national saving resulting from the reduced storage losses envisaged in the project. Participation of an economist in the project on regular or full time basis would enhance estimation of the other economic benefits mentioned above.

Of the six economic benefits listed above, only the first (reduced grain weight loss) and the fourth (selling higher quality grain at higher prices in the local market) are considered in this analysis.

Tables I, II and III indicate the savings to the farmers as the result of using the three types of recommended storages. These are:

(i) Raised Platform Basket.
(ii) Two section crib.
(iii) Improved traditional basket.

The total grain loss estimated by experts involved in the project is 16% which are reduced to 5% by using early harvest, drying, appropriate grain storage and management (Annex E). The analysis in the tables uses the above parameters. The economics of using the 3 types of cribs has been indicated by using a rural market price of KShs 300 ($18.75) per bag for payback A in all the 3 tables and NCPB price KShs 188 ($11.75) per bag for payback B.

The farmers realize high returns on investment with any of the structures by selling the maize in rural markets, possibly 3-4 months after harvest. The shortest payback period to the farmer is for the improved traditional basket and this is 1.3 years, or a return on investment of almost 80%. The highest payback period is

3.5 years resulting in 28% return on investment (a fully purchased two section crib and selling to NCPB).

The improved post maturity technology can be highly profitable to individual farmers but depends on the drying and storage construction costs and selling or not buying grain at rural market prices rather than the NCPB purchase price.

TABLE I ECONOMICS OF RAISED PLATFORM BASKET

	US$	KShs
a) Average cost of construction	63.79	1021
b) Harvesting and shelling costs	12.50	200
c) Cost of insecticde to treat 24 bags	2.63	42
d) Cost of 24 gunny bags (to be used for 2 years)	32.25	516
e) Gross value of 24 bags of grain after 16% grain loss	410.25	6564
f) Net value of 24 bags of grain after 16% grain loss less shelling and harvesting costs	397.75	6366
g) Gross value of 24 bags of grain after 5% loss	459.75	7356
h) Net value of 24 bags of grain after 5% loss g-(b + c + d/2))	436.55	6985
i) Net gain for the grain loss reduction	38.80	619
A. Payback Period (local market prices 1.7 years		
j) Gross value of 24 bags of grain after 16% grain loss	236.88	3790
k) Net value of 24 bags " " " " " (j - b)	224.38	3590
l) Gross value of 24 bags of grain after 5% loss	267.90	4286
m) Net value of 5% loss (l - (b+c))	252.67	4042
n) Net gain for the loss reduction	28.29	452
B. Payback Period (NCPB purchase price) 2.3 years		

NOTES: The Raised Platform Basket has an average capacity of 12 bags of 90 kgs shelled grain. The calculations are based on 2 seasons per year. The gunny bags may be used for 2 years; therefore half of the cost is used in the calculations. In (e), (f) and (g) the full value of the gunny bags is included in total and gross values. NCPB reimburses the full cost of new gunny bags so these are excluded from calculations (j - n). For payback period A, rural market price of KShs 300 ($18.75) per bag has been used. For Payback period B, NCPB price of KShs 188 ($11.67) per bag bas been used.

TABLE II ECONOMICS OF TWO SECTION CRIB

	US$	KShs
a) Average cost of construction	$102.42	1639
b) Shelling and harvesting costs	30.25	484
c) Cost of insecticide	5.25	84
d) Cost of 50 gunny bags	67.19	1075
e) Gross value after 16% grain weight loss	854.69	13675
f) Net value after 16% grain weight loss (e-b)	824.44	13191
g) Gross value after 5% loss	957.81	15325
h) Net value after 5% loss (g - (b+c+d/2))	890.62	14250
i) Net gain for the loss reduction	66.18	1059

A PAYBACK PERIOD (local market prices) 1.5 years

j) Gross value after 16% grain weight loss	493.50	7896
k) Net value after 16% grain weight loss (j-b)	463.25	7412
l) Gross value after 5% loss	558.13	8930
m) Net value after 5% loss (l - (b+c))	522.63	6362
n) Net gain for the loss reduction	29.13	466

B PAYBACK PERIOD (NCPB prices) 3.5 years

NOTES: The Two Section Crib has an average capacity of 25 bags of shelled grain. The calculations are based on two seasons per year. New gunny bags can be used for 2 years, hence half of the value of new bags is used in the calculations. The gross and net values in (d), (e) and (f) includes the total value of the new gunny bags. NCPB reimburses the full cost of new gunny bags and these are excluded in calculations (j - n). For Payback period A, rural market price of KShs 300 ($18.75) has been used while for payback period B, NCPB price of KShs 188 ($11.75) has been used.

TABLE III: ECONOMICS OF IMPROVED TRADITIONAL BASKET CRIB

	US$	KShs
a) Cost of improving traditional basket crib	31.25	500
b) Shelling and harvesting costs	12.50	200
c) Cost of insecticide	1.75	28
d) Cost of 16 gunny bags	12.50	200
e) Gross value after 16% grain weight loss	264.50	4232
f) Net value after 16% grain weight loss (e-b)	252.00	4032
g) Gross value after 5% loss	297.50	4760
h) Net value after 5% loss (g - (b + c + d/2))	277.00	4432
i) Net gain for the loss reduction	25.00	400

A PAYBACK PERIOD (local market price) 1.3 Years

j) Gross value after 16% loss	157.94	2527
k) Net value after 16% loss (j - b)	145.44	2327
l) Gross value after 5% loss	178.63	2858
m) Net value after 5% loss l(b+c))	164.38	2630
n) Net gain for the loss reduction	18.94	303

B PAYBACK PERIOD 1.7 Years

NOTES: The improved basket has an average capacity of 18 bags shelled grain. The calculations are based on two seasons per year. New gunny bags can be used for 2 years, hence half value of new bags is used in the calculations. The gross and net values in (d), (e) and (f) includes the total value of the new gunny bags. NCPB reimburses the full cost of new gunny bags and these are excluded in calculations (j - n). For Payback period A, rural market price of KShs 300 ($18.75) has been used while for payback period B, NCPB price of KShs 188 ($11.75) has been used.

Constraints

The administrative arrangement with the Project Coordinator's office in Maseno having to report directly to Nairobi (MOA headquarters) does not allow for easy and quick communication. Decentralization to the Provincial level would permit direct local involvement and thrust at this level which in turn could be directed to the Districts.

The project has frequently been handicapped by delays - some caused by slow administrative decisions and some resulting from importation of goods. Examples include personnel identification, bicycles, kit grants and office furniture.

Close supervision and support of project activities has been hampered by lack of transport especially at the Divisional level. In some Districts (e.g. Kisii and South Nyanza) the projects vehicle has been placed in the District pool and used for general extension.

The cost of structures is beyond the means of many small scale farmers who do not wish to commit their resources for construction. This has possibly reduced the adoption rate in several areas of the project, especially in South Nyanza, Kisii and Busia. The overall observed adoption rate for the structures is less than 1% (probably 0.4 - 0.6%).

The use of local materials and some measure of innovativeness has been restricted due to reliance on specific project recommendations, the absence of an engineer and inadequate time between third year approval and the start of harvest. Adoption rates will be higher and adoption will occur earlier if there are more tested alternatives and if there is minor design assistance available to meet local needs (tradition, social restrictions, unique farm conditions and local materials).

Some example option needs include:

a) Non-storage drying facilities for farmers who store grain in their home.

b) Low cost smaller and divided storages (separating the husband's and wive's grain).

c) Larger dryer and/or storage options for medium scale farmers.

d) Local or alternate material options.

e) Rodent proof storage that doesn't require one meter ground clearance.

Observations and Conclusions Regarding Progress

The list of project accomplishments is impressive. It has created an awareness of post harvest losses. The improved harvest and storage recommendations are recognized by farmers to improve grain quality and decrease labor requirements as well as reducing losses of grain weight. The training efforts have been well focused and successful. They generated motivation as well as imparting knowledge.

The laboratory facility at Maseno will need modifications to assume any of the three alternatives outlined above. It is not designed to perform research of any depth. It is equipped for gathering data and monitoring postharvest grain losses due to birds, insects and molds. The laboratory can be supportive of testing or proof of concept work for technological packages. It is also equipped to detect aflatoxin; a toxic substance suspected of increasing the probability of liver cancer.

However, to be useful, there can not be long delays for sample analysis and result reporting to farmers through the extension staff. The laboratory should have elementary nutrition testing abilities (at least an IR analyser) if it is to function as an extension support facility or as a grain monitoring unit. Significant changes and investment will be required if the laboratory is to fill any of the outlined roles.

The nature of the project necessitates a heavy initial investment for which a payback may not be realized within the life of the project. During 1984, the first project implementation year, actual personnel support was 65% of the total expenditures while expenditures on materials was 20%. Although the proportion of staff salaries and benefits declined to 48% in 1986, expenditure on materials was 26%. Similarly GOK contribution was in the form of salaries, training and other related staff benefits.

Contract expenditures (Annex D)are well below the expected level (42% of total budget on 31 January 1986) largely because of cancellations and purchase delays. Based on project plans for 1987, we estimate that less than 60% of the budget will be expended by the end of the fourth year.

Over 70% of the trained personnel have or will return to their previous positions, but MOA must make continued service attractive. Otherwise the trained people will likely accept positions outside the Ministry. Not all people selected for training were in post harvest work.

It is too early to assess the complete impact of the present group approach being used in the project (clusters and demonstrations). Attendance at field days is high and some good indicators of adoption are present. However, adoption rates for the improved storage management recommendations can not be estimated yet.

The cribs or raised basket drying and storage structures have been awkward in several respects. They are the most visible evidence of a demonstration and therefore are seen as an essential element. Project personnel have tried to counter this perception and to de-emphasize the structures because nearly half of the loss reduction can be realized by adopting the improved management practices that do not require an improved structure (the only capital intensive element). This has been partially successful

because the shelling and treatment recommendations have been adopted by many farmers who have not built improved structures. The improved structures were the primary element in the grain storage management plan that required testing and thus the major extension effort might have started earlier if the early harvest and drying had not initially been included. Finally the facilities for drying and storage are the part of the program that is most sensitive to farm size, social conditions and climate. Thus numerous structure options are needed (designed and tested) and the extension staff must have the experience and training to recommend the most appropriate options for each farmer.

Extension staff (from District through sub-Location levels) are seriously handicapped by lack of adequate transportation.

Recommendations

The laboratory was neither designed for, nor easily converted to a research (generation of original ideas and creation of original solutions to problems) facility. The laboratory could with more equipment, modified methodology and technical leadership, become a regional grain monitoring unit. However, this is valuable only if it is part of a national system of such laboratories. We do not have any evidence that the national system is being developed.

The best option appears to be modifying the facility into a regional (western Kenya) extension investigation center. Services might include soil testing, identification of disease and insect pests, monitoring a suspective invasion of foreign pests, minor design support, assistance in assembly of material for presentation to frontline extension staff, providing testing/demonstration facilities for extension specialists and undertaking testing or proof-of-concept work based on research results and appropriate for extension in the region.

Such a facility should have a manager who administratively is responsible to a Steering Committee composed of the three PDA's and representatives of LBDA, ICIPE, KARI and the MOA Information Center thereby assuring that the center serves the entire region and interfaces with related activities.

Other professional staff should include a communication specialist, a soil chemist, an entomologist (or a pest management specialist), a microbiologist/mycologist and an agricultural engineer. Several clerical staff and laboratory technicians should also be employed.

Other recommendations for the laboratory which are valid regardless of whether it is a grain monitoring unit or an extension support facility include:

1. Enlist the services of a Postharvest Pest Management Specialist who has competency in laboratory analysis, with a background in training laboratory personnel in routine analysis and laboratory administration.

2. Update the GMU laboratory manual to include all procedures for all tests and how to assemble data for reports.

3. Modify the methodology for testing aflatoxin. Observe the ground sample under ultraviolet (UV) light. Record presence of bright green yellow fluorescence (BGVF), (the presumptive test for the presence or absence of the fungus capable of producing the aflatoxin). Verify only those samples that have a positive reading using the minicolumn, Holiday-Velasco method. Make a quantative estimate of the positive samples using the minicolumn method.

4. Change to methodology for the presumptive aflatoxin test to viewing the germ face thus reducing preparation time and labor.

5. Change laboratory procedures to assure uniform quality performance and train part-time technicians to assure rapid sample turn-around time.

Extend the existing project one more year as stated before. In terms of project performance, the time extension is needed to: a) assure continuation of the extension effort; b) allow continued support of the six M.S. students; c) design and test other drying and storage options (which is critical to the adoption rate); d) implement the kit grant program (also important for increased adoption); e) re-address the transportation issue with first emphasis on bicycles and motorcycles; f) attempt to have at least one demonstration farmer in each TA's area; g) increase the emphasis on women's and youth groups (women handle grain more than men in this area); and h) training materials (paper, chalkboards, charts, etc.) should be made available to LEOs and TAs to use during training.

Because a primary output of this Project is a program that is to continue beyond the Project, the Project must prepare the program for the transition from Project supported to independence. This transition is difficult because key people and other resources are withdrawn. However, the Project can facilitate the transition by: (a) trying to be as transparent as possible while continuing to be a very active catalysts, b) being sure that people identify with the program rather than the project, and c) gradually shifting Project personnel from the highly visible motivator, initiator, expert role that was essential at first to a behind the scenes support-through the counterpart-role. Specifically we recommend that the Project's administrative office including the CPC and Project Manager be in close proximity to the PDA's offices. The Project should try to identify itself through the Provincial Agriculture offices by having personnel use common stationary, addresses, telephone numbers and other identifiers with their counterparts.

The baseline survey and economic information has not been collected and analysed. This means that the extension program doesn't have the economic information it should be telling farmers and economic impacts of the program have not been determined.

The current drying and storage options that are offered to farmers are good, but other options are needed to meet the needs of some farmers. This will negatively influence the adoption rate identified as a critical component in the cost/benefit analysis of the program in the project paper.

If the project is continued, we strongly recommend that the vacant positions be filled. If there are qualified persons available in the extension system, they should be identified. If that fails, qualified persons should be found in MOA, Kenya or in other countries (perhaps as short term consultants).

Inadequate transportation for extension personnel frequently handicapped or reduced their effectiveness. Part of the problem is from purchase delays, while part is due to insufficient operating vehicles or operating funds in district offices. We recommend that this problem be given careful consideration. In some instances, support for maintenance or operating expenses might reduce the problem.

The required training for most staff can be achieved in country and should be planned accordingly.

a) Institutions should be approached to develop curricula on grain storage (short courses and resident programs). The institutions should work jointly and include MOA, KARI, ICIPE, and project personnel in the planning.

b) In-service training sessions (2-3 annually) should be organized for field staff.

c) Overseas trainers could be hired if desirable for short periods.

d) A stock of local trainers should be identified and be charged with the responsibility to organize continuous training.

e) Preferably only those working in the program should be selected for overseas training; and they should be expected to return to the project at the end of their training.

EXPANDED PROJECT

Unlike the DESIGN and PERFORMANCE sections, this section integrates observations, conclusions and recommendations with each subsection. This section is also less complete in as much as we have attempted to not repeat concepts developed in the previous sections.

Rational for an Expanded Project

There are at least four major issues that influenced our recommendation on project expansion: available opportunity, micro economic profitability, compatibility with national goals, and economic impact on the country.

Opportunity

According to the Pfost (DPRA) study, grain losses appear to be high throughout Kenya. We question geographical loss uniformity, based on a small current study at Egerton College. Most of the maize in the surrounding area is grown on farms of 2-10 ha. The maize is field dried and then simultaneously harvested, shelled and sold to NCPB. Usually no more that two bags are retained for family use. Thus for most of this maize there is no storage loss. Assuming that field losses are typical, the preventable

losses may not be more than 6%. Reportedly, stored grain insects are not a major problem in the small quantities that are stored. Most of this area is at higher elevations (hence lower temperatures) and thus insect activity is reduced. The larger farms and reduced quantity of stored maize also help inhibit storage insect problems.

Even if significant variation in loss rate occurs, we believe there are wide spread opportunities to improve on-farm storage. Even in areas where the maize is sold immediately after harvest, storage might be considered if the pricing or marketing policies changed. Alternatively, early harvest and drying might be desirable even with immediate sale if appropriate technologies were developed and demonstrated.

Profitability

In previous sections, the current program has been shown to be beneficial to farmers adopting the improved practices in western Kenya. This appears to be true economically, nutritionally, for food safety and for organoleptic quality. The improved methods have also been reported by farmers to reduce labor requirements (periodic in-storage handling and sorting is eliminated). Thus in the Western and Nyanza provinces, adoption of improved practices appears to be economically advantageous for farmers. We believe this will be true in most maize growing areas if appropriate technological changes are made in the recommended practices.

Compatibility

Kenya's food security policy is self-sufficiency in basic food commodities and especially in maize which is the main staple food. The rapid increase in population and the continuous decline in good agricultural land per capita calls for stringent measures

to reduce grain losses. A 11% grain loss decrease is equivalent to 13% increase in grain production. The current on-farm grain project will enhance food security at the farm level and subsequently the aggregate food security at the national level. On the other hand the on-farm grain storage program will enhance increased farm income especially among the poorest farmers and this will contribute to one of Kenya's national goals of raising living standards for disadvantaged Kenyans.

The program goals are consistant with national priorities.

Economic Impact

The adoption rate for farmers constructing their own cribs is estimated (by crib count) at 0.4-0.6%. This low percentage is mainly because the intensive extension phase of project started in mid 1986 and partly because the costs of recommended cribs are not within the financial capability of some farmers. Adoption of shelling and insecticide treatment is estimated (by insecticide purchases) at 10% resulting in an overall adoption rate of 6% in the first year. The consultants estimate that adoption rate will progressively increase to 25% by the year 2001 assuming current levels of investment which is mainly in training, and testing. But with additional investment in extension support, crib construction materials, insecticide, gunny bags and development and testing of alternative facilities the adoption rates may increase considerably.

ANNEX G covers

ANNEX G covers the western Region, that is Western and Nyanza Provinces which was the project area. Calculations in ANNEX G are based on 6-25% adoption rates between 1987 and 2001. The value of reduced losses, that is by 11% range between $583,363 in 1987 to

$2.8m in the year 2001 while the total saving in the period is $26.9m. The benefit to cost ratio with at 15% discount rate for the region is 1.16 while the break-even adoption rate is 10%.

It was rather difficult to estimate the project input costs, especially GOK's, after 1987. It has been assumed that GOK's input will remain at around 1986 level, some $236,986, hence $300,000 is estimated to be GOK's input into the project after 1987. Once the project expands into Rift Valley which is mainly medium to large scale farming area the types of cribs suitable for the region will have to be larger in size and this has not yet been tested. Therefore, with all these uncertainities, it is illogical to extend cost benefit analysis outside the current region. However, this exercise can be carried out after detailed economic analysis of data which will have to be assembled in the current project region.

The rational for an expanded project appears to be solid except for the unknown adoption rate. Our estimate of 25% by 2001 has a high degree of uncertainty since there is very little evidence this early in the extension effort. Surveys should be taken periodically to better define the likely adoption rate.

Until the adoption rate estimates justify an expanded project, the current extension efforts should be continued and intensified. Special attention should be given to transportation for extension staff, training materials, kit grants, demonstrations, demonstration farms, increased technical solutions and training for extension staff.

To the extent possible, the program should involve other agencies. The only KGGCU involvement has been in the supply of chemicals to the farmers. Since grain loss is of significant importance to the country as a whole, and to the region in

particular, some other organizations could also be involved in this effort. These organizations include (a) the churches - which have several development activities in the area (b) NGO such as Action Aid which works with small scale farmers (c) LBDA which has imported and initiated several self-help projects in the area, and coordinates other Government assisted projects and (d) ICIPE whose research capability on insects and association with the lab would be of paramount importance.

Many factors influence the adoption rate. The extent to which these are addressed by the current and potential expanded programs will essentially determine their success. The major factors can be summarized as capital cost, social pressures and tradition/non-logic based perceptions. Most of these factors primarily influence construction of drying/storage units and thus control only half of the loss reduction.

Capital Cost

The capital cost for constructing a crib or raised basket has been identified as an adoption constraint earlier. This constraint can be reduced by the following:

a) Materials for construction, if available, should be of local origin. The variability in the costs of constructing cribs is high. For the storages constructed using purchased materials including hired labor, the costs are KShs 1,020.60 for the raised basket crib KShs 1,638.75 for the two section/crib, and KShs 500.00 for the improved traditional crib. Whereas, if the farmers use materials obtained in the immediate neighborhood, the cost ranges between KShs 240-500 per structure. This will require minor design assistance to be available. In some instances, more testing of drying and storage options may

be required. Implementing this recommendation gives incentive to local suppliers and is consistant with the GOK policy of localization in development activities.

b) Credit for capital improvements as well as operating or production costs needs to be available. Banks and other credit lenders should be approached with economic information on improved post-harvest grain management. If the usual sources of credit are unwilling to assist, the program may need to provide credit to farmers.

c) Assistance, as envisaged in the kit-grants, should be made available - especially to the most needy farmers.

d) The farm management specialist or economist position, has not been filled. Economic viable data is not available to farmers.

We recommend that a farm management specialist be attached to the project to co-ordinate useful data collection, analysis and interpretation. This is important not only for farmer recommendations but also for program evaluation and for discussions with credit lending institutions.

Social

Some social factors are uniform over broad regions, but others are unique in a location or sublocation. Regardless of scale, they are important and, if ignored, may reduce the adoption rate to zero. We recommend the following:

a) When expanding, anthropological studies (like the one done for this project) should be undertaken to determine the most suitable structure type (if any), size and economic

implications as well as social/economic/agricultural patterns.

b) Have the capability within the program to design and test alternative management recommendations to meet unique social requirements.

c) Be sure the extension focus or contacts are with the appropriate family member. Frequently food (grain) production and handling is the woman's role and thus women's groups are valuable contacts. However, capital expenditures are frequently controlled by the male family member. When that is true, other communication methods must be used.

Tradition

This is perhaps the most difficult adoption constraint with which to deal effectively. Tradition or other non-logic based perceptions are frequently deeply ingrained and not subject to reason or concrete evidence. Probably the best approach where these factors are a constraint is to involve both children and parents. At best, changes will be very slow and some efforts may have a negative impact. These constraints are very common, especially in some divisions.

Many of these recommendations are already part of the existing project or program.

Major Components

Once the adoption rate has been demonstrated to be adequate, we believe the program should be expanded geographically to other maize growing regions (ANNEX H). The extension of on-farm grain

storage program will depend on prevailing farming systems and the socio-economic factors. Cultural factors may inhibit or enhance adoption of on-farm storage technology. Large drying or drying and storage structures may be preferable where large farm sizes predominate. The pricing structure if controlled, should include the cost of storage over time. In such a situation the farmers can afford to pay for large storage structures which will presumably be more profitable.

Initially, if not accomplished by the present project, the Lugari division of Kakamega and the Kehancha division of South Nyanza should receive attention. Both areas have larger farms; larger harvests and need larger cribs. The Kericho and Nandi districts of the Rift Valley have similar farming systems to the current project region. They appear to be natural early expansion areas if they have not been included in the SIDA project.

We envision a phased program expansion. New geographical areas should be selected so as to minimize the program changes - that is, expansion should be into regions with similar climate, farm size, agricultural practices and social conditions. Before moving the extension program into the new region, anthropological and technical studies will be needed to identify likely program changes and to confirm the opportunity. Testing of program modifications (usually involving the drying or storage facilities and possibly extension methods) should be undertaken as early as possible. The amount of this work required should decline as the program expands. Even though it is not possible to assure an adequate adoption rate, we suggest that this work be initiated for the first expansion region during the fourth year of the current project (if approved).

Training and the subsequent intensive extension program can begin as soon as the testing results validate the proposed program.

During this phase, the study and testing phase can be moved to another region. This phased movement will level the resource requirements for training, study and testing and will minimize the effort required for each expansion step.

The laboratory plan outlined in the previous major section could be a valuable asset in the expansion into nearby regions. It could support both the technical study and the testing activities.

There appears to be significant opportunities to improve post-maturity practices for other crops. Very high sorghum loss rates have been reported and questioned. Post harvest bean losses are reportedly low, but the estimate did not include quality losses which can be very high due to the hard-to-cook phenomena. Both weight and quality losses are thought to be very high in potatoes but we don't have reliable quantitative information.

We recommend that the program first expand into new areas addressing maize losses. As the effort becomes established in a region, other crop opportunities can be studied - perhaps with technical assistance from the laboratory and when necessary from external consultants. As opportunities are identified, the studies and testing required to develop a good extension effort can be initiated. With a cadre of trained and experienced maize storage specialists available, in-service training efforts will usually be adequate to extend their abilities to a new crop.

Possible Modifications

Most program modifications were identified in the Rational section. As the project expands, we would expect a higher percentage of the resources to be devoted to the extension program (staff and support resources). Studies and testing will only be needed for the differences between regions. The criteria

identified in the current project for demonstration farmer selection appear to be appropriate, but skewed the selection to the more progressive, the more wealthy and those who have received other grants. This may have been necessary, but not consistant with the project focus on poor smallholders. Kit grants should be focused on the poorer farmers.

Assuming that there will be a project associated with a program expansion, we suggest the following functions for project specialists/advisors:

a) Planning and coordination support at the Provincial Headquarters.

b) Organizing training for field staff in liaison with PHSO. at District and Divisional levels.

c) Developing and delivering training materials and equipment to support trainees at ground level.

d) Monitoring progress by farmers in each District and helping in compiling feedback information from field staff for planning and modifications.

e) Providing collaborative effort with other organizations involved in similar activities such as the SIDA-RSU project.

f) Providing technical expertise when Kenyan experts are either unavailable or can't be assigned to the project.

g) Injecting enthusiasm and motivation into the program. At first this must be direct, but should be channeled through the counterparts as early as possible.

In addition the project must have a coordinator/team leader to provide administration for the contractor and to coordinate activities with the PDAs in the region.

Relationships and Integration

RSU - SIDA

This project, originally sponsored by FAO and now supported by SIDA, was working on farm structures. They are now focusing on post harvest maize drying and storage. At present they are working primarily with larger farms in the Rift Valley. The program they are now supporting is nearly identical to the on-farm grain storage effort. The SIDA project plans to expand geographically in 1987 - primarily north and east.

The SIDA project has its greatest personnel strength in structural design. This compliments the on-farm grain storage projects strength in extension and the capabilities proposed for the laboratory. Without the capabilities proposed for the laboratory, both projects are missing critical expertise in grain storage engineering, pest management and mycology. With or without the proposed laboratory, both projects need a farm management economist.

Close official and unofficial cooperation and coordination between these two projects is essential. Already the two projects have been unofficially cooperating on may things - sample testing, extension materials and facility design. Official coordination is needed to avoid duplicated effort and to meet critical resource needs most economically.

Research - Extension

The program thus far has concentrated on encouraging farmers to adopt existing, but improved on-farm grain storage technology or management practices. With this focus, there has been little need for KARI involvement.

A continuing on-farm grain storage extension program needs research support. Some immediate research/testing/design needs include:

1. Alternate structural materials for cribs and raised basket stores.

2. Improvement of in-home storage.

3. Alternate methods of protection from rodents in unraised cribs.

4. Alternate grain drying and storing methods in high theft areas.

5. New hybrid maize varieties with satisfactory husk coverage.

6. Alternate structural designs for storing other crops.

7. Lower cost roof coverings.

8. Non-storage low cost grain dryers for large growers or farmers storing in their home.

9. Facilities for larger and smaller producers.

10. Facilities appropriate for areas with higher temperatures or relative humidities (such as parts of the Coast and Rift Valley provinces).

11. Less capital intensive recommendations for locations where conditions permit lower cost alternatives.

12. Moisture isotherms (equilibrium relative humidity - moisture content curves for different temperatures) and safe (from excessive mold growth) drying time curves.

Some of these needs require only design, testing or demonstration of existing technology while others should be a research objective. We recommend that KARI undertake work on as many of these topics as fit within their program and for which they have resources. The proposed laboratory could undertake the design and testing efforts.

NCPB, Marketing and Pricing Systems

The NCPB serves several important roles in Kenya:

a) assures grain price stabilization;

b) provides storage for strategic grain reserves;

c) procures grain to meet the government needs;

d) provides information on grain reserves and movement to government planners; and

e) is a mechanism for grain transport within the country and for import/export.

Theoretically, all marketable maize surplus should be handled by the official marketing channel through NCPB. But in practice two distinct sub-systems complement each other. NCPB mainly handles maize produced by medium and large scale farmers, but to a certain

extent buys surplus maize produced by small scale farmers. Moving grain in excess of two bags across district boundaries or ten bags within a district should be handled by NCPB which is supposed to hold a monopoly over inter-district maize movement. It organizes transactions and transfers using rail facilities in the country and issues movement permits to private millers and individuals. Strict enforcement of movement control inhibits inter-regional maize trade even when maize deficit and surplus regions may be adjacent to each other.

Rural markets are organized in rural trading centers and are mainly patronized by small traders and small-scale sometimes subsistence farmers.

While NCPB is supposed to influence the prevailing prices in these markets by injecting or siphoning maize, the markets in practice operate under rules of supply and demand.

The rural and the official maize marketing systems interact and there appears to be some overlapping in their functions. The official marketing system has the power as well as the machinery to influence the traded volumes and the prices in the rural markets. It is the largest stock holder of maize in the country and could easily support competitive forces in local markets to an extent that gazetted prices are achieved.

However, in times when the official marketing system is unable to supply maize to deficit areas, local prices rise, and large quantities of maize appear to be supplied through the rural markets. Rural market traders usually respond to these localized demands by smuggling maize across district boundaries.

The on-farm grain storage project has a central role in the development of Kenya's grain marketing system in either of the following grain marketing scenarios:

a) Liberalized grain trade: In the short-run the rural markets may not cope with surplus marketable grain in Kenya. They are relatively undeveloped. When the rural markets are fully developed, they will be able, possibly, to handle large volumes of grain. In such circumstances medium and large scale farmers and traders will have incentives to store grain on their farms or in other storage facilities and release the grain into the markets when prices are favorable. For the next 15 years or so, the on-farm grain storage project can only cushion the marketing forces in rural markets.

b) Graduated market price: The system would encourage the farmers to store grain on their farms a little longer after harvesting. The graduated price incentive would result in higher returns for the farmer who stored grain on the farm. The medium and large scale farmers will be willing to invest in large scale grain storage structures on their farms if the price graduation is adequate.

c) Present market policy: Under the existing marketing policy described earlier there needs to be a relaxation of grain movement controls especially within the districts to enhance development of rural markets. The small-scale farmers would be in a position to store grain for a longer period after harvest and thereby benefit from higher local market prices. The incentives for the medium and large scale farmers encourage immediate sale after harvest and shelling.

The on-farm grain storage project will enhance grain market development, especially the rural markets where 60% of the grain is traded. With active participation of small scale grain producers and consumers, each party will reap maximum returns.

The on-farm grain storage project will also play a significant role in Kenya grain storage by providing storage facilities at the farm level where the grain is usually required a few months after harvest. In western region an additional 146,638 tons will be stored on farm at the assumed adoption rate of 25% of improved storage technonology. This will represent an indirect saving of national grain storage structure construction.

ANNEX A

EVALUATION TEAM ASSIGNMENT

Article I - Title

On-farm grain storage - Evaluation (615-0510-ARDN)

Article II - Objectives

The objectives of this work is to provide assistance to the USAID/Kenya Mission in the Mid-project evaluation of the On-Farm Grain Storage Project.

Article III - Statement of work

A. Project Background:

1. Project Purpose: To increase the use of more effective on-farm grain drying and storage practices in Kenya.

2. Project Implementation Strategy: The present project implementation strategy, designed to achieve the above purpose, involves testing and adapting existing on-farm grain drying and storage technology to local conditions in the Nyanza and Western Provinces of western Kenya. This is achieved through extensive participation of farmers in the identification of acceptable practices and through controlled testing on smallholder farms.

   Proven technological packages (practices, materials, equipment and structures) for appropriate micro-ecological areas are being demonstrated on smallholder farms. At the same time, to insure the spread and maintenance of the

benefits gained, effective methodologies to promote the widespread use of suitable technological packages among western Kenya's smallholders are being defined and strenghthened; the capability of the Ministry of Agriculture (MOA) to monitor, evaluate, and expand on-farm grain storage services to farmers is being enhanced; and the capability of agriculture educational institutions to teach grain drying and storage is being increased.

3. Project Beneficiaries: The primary beneficiaries are poor agricultural households, poor smallholders, who constitute 42 percent of the nation's smallholder population and contain most of the country's low income consumers. Geographically the project focuses on the Western and Nyanza Provinces of western Kenya. The emphasis is on the poor smallholder of these areas. Farmers who adopt the applied techologies benefit by reduced on-farm losses and food contamination by mold (including aflatoxin), vermin waste and improperly applied pesticides.

A second category of beneficiaries are those who become part of the field testing, demonstration, and expansion systems developed and strengthened as part of this project. A third, more general category, is comprised of those citizens throughout the region who will benefit; (a) from the increased availability and quality of foodstuffs and (b) from GOK savings resulting from the reduction of necessary purchasing, handling, and transporting of food grains into the remote western Kenya area.

4. Project Outputs: The original project outputs include:

a) Creation within the Ministry of Agriculture (MOA) the capacity to stimulate interest and participation of smallholders in identifying grain drying and storage problems; to organize the field trials necessary to test and adapt technology to local conditions; and to conduct demonstrations of that technology. (The Field Testing and Demonstration Unit - FTDU).

b) Improved MOA capacity to facilitate adoption of appropriate on-farm grain drying and storage technological packages by smallholders. (Post-harvest Storage Branch and Extension Service).

c) Increased capability of agriculture educational institutions to provide training in on-farm grain drying and storage technology. (Embu, Bukura, Egerton and University of Nairobi).

d) Creation of a Ministry of Planning/Central Bureau of Statistics (MOP/CBS) unit to monitor and evaluate stored grain losses. (The Grain Monitoring Unit - GMU).

e) Written reports and recommendations regarding the need for financial assistance to smallholders to support grain drying and storage activities and the most effective delivery systems.

f) Written report of the Contract Project Team Leader regarding how best to expand this initial regional effort on a nationwide basis.

5. Funding: Funding is provided through a $7.8 million AID loan and the Government of Kenya (GOK) contribution is $3.9 million for a total project cost of $11.7 million. The AID contribution consists of $3.6 million for technical assistance, $0.9 million for training, $0.5 million for construction, $1.1 million for commodities, and $1.7 million for contingencies and inflation.

6. PACD: Original June 1, 1986
Revised June 4, 1988

7. Contracting: All technical assistance, training functions and a major portion of the procurement is included in a $6.8 million host country contract with Development Planning and Research Associates, Inc (DPRA). Work under the contract began late 1983. It is anticipated that the present contract completion date of April 30, 1986 will be extended until April 30, 1987.

B. Purpose of Evaluation: General: To perform a comprehensive evaluation of the On-Farm G.in Storage Project to determine its impact on reducing post harvest storage losses in the project area, including technical and economic considerations; and secondly, the feasibility and appropriateness of expanding the scope of USAID's on-farm grain storage efforts to include a larger geographic area of the country.

Specifically the project is being evaluated to:

1. Measure impact of the project to date on reducing grain loss. Determine the benefits of the project to Kenya to date, the future benefits likely to accrue, and any constraints which must be resolved to ensure benefits will be obtained. The evaluation should suggest options and the costs of dealing with constraints.

SP

2. Determine progress toward attaining the objectives of the existing project within the time and resources available.

3. Determine validity of existing project objectives in light of implementation revisions resulting in reducing the implementation period from 4 to 3 years with a proportional reduction in T.A. and training.

4. Explore the feasibility and possible mechanisms of developing an expanded On-Farm Grain Storage Project. This activity would include a procedure for phasing into the implementation of an expanded program and establishing a fit with GOK grain liberalization policies.

C. Major Evaluation Areas: The contractor will be required to evaluate three major areas primarily for the purpose of determining the progress to date, and feasibility and background information for outlining the basic design of an expanded project. The scope of work for the evaluation will include but not be limited to the following:

1. A analysis of the validity of the existing project design and assumptions upon which the design was based in terms of the achievement of project goal, purpose and end-of-project-status (EOPS). Recommended modifications to the existing design as necessary.

2. Evaluation of the progress to date toward achievement of stated project outputs and EOPS, and identification of those constraints existing both within the project and external to it (such as in the bureaucratic, political, economic, environmental and social spheres). This activity will be conducted primarily for the purpose of evaluating the experience that has been acquired to date and formulating a basis for an expanded program.

3. The relationship of the implementation of the project to the Ministry's broader efforts to extend on-farm grain storage technology to areas outside the project target area. Recommendations on modifications of the project in light of this development will be made. The evaluators should outline the major components and activities of an expanded effort, if such an effort judged feasible. This outline should include:

   a) strategy and policy justification of the scope of an expanded On-Farm Grain Storage Research and Extension Project;

   b) criteria for determining the geographic scope of an expanded project;

   c) the major components that would be included;

   d) implementation options for phasing into an expanded project; and

   e) the "fit" of the existing project and potential new activities with GOK grain liberalization policies.

D. Specific Evaluation Activities: In an effort to gain an overview of the present project and the potential of an expanded on-farm grain storage the contractor should address the following:

1. Benefits to the project area to date, including:

   - quantify the adoption coverage of improved on-farm grain storage technologies by numbers of smallholder farmers;

- increased knowledge and awareness by smallholder farmers of grain storage loss and the means to control it;

- quantify reduction in on-farm grain storage losses in physical and economic terms; and

- improved capability of the MOA extension officers to extend improved grain storage technology.

2. Assessment of the effectiveness of project inputs or components funded by USAID and the GOK including such things as:

a) The type, number, qualifications, timeliness of arrival and scopes of work of U.S. provided technicians: their integration into designated project activities, relationships with GOK counterparts, USAID personnel and other donors and organizations; the effectiveness with which they have been utilized; the appropriateness of their duty stations, etc..

b) Academic and non-academic training, including on-the-job training, in terms of its contribution to meeting project objectives.

c) Effectiveness of project inputs in terms of quality, timeliness and value in meeting project objectives.

d) The basic work of each technical advisor position in terms of contribution of the position and the individual(s) toward the overall success of the project.

e) Assessment of factors accounting for successes/ failures to date. Such factors are many and will emerge as the evaluation proceeds. Some potential factors are suggested below.

3. Feasibility of expanding the project's activities beginning April 1987.

4. In addition to the above, specific attention will be given to:

a) assessing GOK grain pricing and marketing regulations and policies and their impact on farmer's decisions to improve on-farm grain storage units. Evaluation should include specific recommendations designed to improve policy.

b) the T.A. requirements for an expanded on-farm grain storage effort. Indicate the appropriate type of T.A. (Kenyan or expatriate) in view of the Government's position on expatriate T.A. Given the fact that the use of expatriate specialists may be limited in the future, alternative methods for procuring technical assistance should be evaluated.

c) the planning and implementation of the extension education phase of the project. This is a major activity of vital importance and its implementation will determine the degree of success that the project achieves and may be a major activity in future projects. The evaluation should look closely at progress to date and the planning for the balance of the extension program.

d) an assessment of the integration of the project into the Ministry's field program. Specific recommendations for achieving better integration with the agricultural extension and research programs will be made.

e) the involvement of various private sector organizations, companies, etc. in the project. The project was not designed to incorporate the private sector extensively. Nevertneless, it now appears that more, possibly extensive, private sector involvement is indicated. Careful attention to the involvement of women's, church, producers and cooperative organizations and associations in the project should be an important part of the evaluation. Specific recommendation on enhancing private sector involvement should be included.

f) efforts that can be made to expand and move forward more rapidly the extension education program. The extension education program including the extensive construction of field demonstration units is of keen interest to the GOK as it is to all others involved in the project. The evaluation should include extension education progress to date, present implementation efforts and recommendations on how best to achieve the desired results in this area.

E. Reports: A draft outline of the topics to be included in the final evaluation report will be discussed with the MOA and the mission no later than 20 days from the initiation of work in Kenya. Copies of the draft evaluation report, addressing the items in the scope of work, are to be made available to the MOA and the USAID Mission at least seven days prior to the team's departure.

Team members will make themselves available during this period for reviews and discussions of the draft with USAID and MOA officials.

The final copy of the evaluation report and recommendations will be forwarded via Unclassified Air Pouch to USAID/Kenya within thirty days of departure from Kenya.

F. Evaluation Team - The evaluation team will consist of four principal members as follows:

1. Agricultural Project Planning/Management Specialist (U.S.)
2. Grain Storage Specialist (U.S.)
3. Agricultural Economist (Kenyan)
4. Extension Education Specialist (Kenyan)

Two of the specialists should be hired from the U.S. and two from Kenya. One of the U.S. specialists will be designated the team leader by the contractor. This individual will be responsible for supervising the other three team members and coordinating all activities related to carrying out the evaluation. AID and MOA On-Farm Grain Storage Project managers will work closely with the evaluation team and serve as ex-officio members of the team.

G. Job Descriptions

Agricultural Project Planning/Management Specialist (Team Leader):

- has overall responsibility for managing the evaluation.

- represents the contractor in screening applicants and in selecting and hiring local consultants (Kenyans).

- in conducting the evaluation, coordinates with the USAID and MOA On-Farm Grain Storage Project Managers and with other appropriate personnel from these organizations.

- conducts an evaluation of an provides written material on the overall planning, management and implementation of the On-Farm Grain Storage Project.

- provides leadership and direction to the evaluation team in developing an overview of an expanded on-farm grain storage program.

- responsible for developing the format of the evaluation, defining individual responsibilities of the consulting team members, scheduling work activities, developing the evaluation outline and submitting the final evaluation report to USAID/Kenya and the MOA.

Grain Storage Specialist (U.S.):

- has specific responsibility for evaluating the technical aspects of on-farm grain storage conducted and planned under the present project.

- evaluates the technical aspects of the on-farm and Farmer Training Demonstration Units (FTDU) storage trials.

- responsible for identifying the technical areas of on-farm grain storage that are the most likely to produce positive benefits to farmers under the existing project and as activities of an expanded on-farm grain storage effort.

- responsible for evaluating the On-Farm Grain Storage Research Program and developing specific recommendations

for future research efforts including identification of research needs and the key elements of future research programs.

responsible for evaluating the technical material being developed for use in the extension program.

Agricultural Economist:

- based on current research and field experiences of extension, project personnel and knowledgeable farmers, evaluates the economics of existing and planned on-farm grain storage field recommendations.

- evaluates the cost benefits of the On-Farm Grain Storage Project to date and projects these benefits to an expanded program.

- evaluates the contribution of on-farm grain storage technology applications to the national grain storage program.

- provides recommendations on the most appropriate role for the On-Farm Grain Storage Project in the general effort to liberalize grain marketing in Kenya.

Extension Education Specialist:

- has primary responsibility for the evaluation of existing and planned on-farm grain storage extension activities.

- responsible for developing the basic concepts to be used in an expanded extension education and field demonstration program.

- takes the lead in reviewing and evaluating existing and proposed extension education materials.

- responsible for reviewing and evaluating the in-country and participant training program.

- takes the lead and organizes input from other team members for the outline of the scope of an expanded participant training program.

- develops methods for evaluating the effectiveness of alternate extension methodologies aimed at the small-scale grain farmer.

ANNEX B

LIST OF ACRONYMS

The following list of agencies, institutions and government positions are related to on farm grain storage in Kenya. For brevity in writing, some of these will be referenced with the following acronyms:

AID - Agency for International Development
AIS - Agricultural Information Service
ASSP - Agricultural Systems Support Project
CBS - Central Bureau of Statistics
CPC - Contractor's Project Coordinator
DAO - District Agricultural Officer
DEO - Division Extension Officer
DPHSO - District Postharvest and Storage Officer
DPRA - Development Planning and Research Associates, Inc.
ES - Extension Specialist
EOPS - End of Project Status
FAO - Food and Agriculture Organization, (United Nations)
FEW - Frontline Extension Worker
FES - Field Extension Staff
FTC - Farmer Training Center
FTDU - Field Trail and Demonstration Unit
GDSE - Grain Drying and Storage Engineer
GOK - Government of Kenya
GMU - Grain Monitoring Unit
HE - Home Economics (Field Technician)
ICIPE - International Center for Insect Physiology and Ecology
IRR - Internal Rate of Return
KARI - Kenya Agricultural Research Institute
KGGCU - Kenya Grain Growers Cooperative Union

LIST OF ACRONYMS

LBDA	- Lake Basin Development Authority
LEO	- Local Extension Officer (Field Extension Personnel)
MOA	- Ministry of Agriculture
MOEP	- Ministry of Economic Planning
MOP	- Ministry of Planning
NAL	- National Agriculture Laboratory
NCPB	- National Cereals and Produce Board
PDA	- Provincial Director of Agriculture
NGO	- Non-Governmental Organization
PHSO	- Postharvest and Storage Officer
ROI	- Return on Investment, Economic
RSU	- Rural Structures Unit
SE	- Storage Engineer
SIDA	- Swedish International Development Authority
SMS	- Subject Matter Specialist
TA	- Technical Assistant
TDRI	-Tropical Development and Research Institute
TPI	-Tropical Products Institute
T&V	- Training and Visits, National Extension Program
TO	- Technical Officer
USDA	- United States Department of Agriculture

ANNEX C

PARTIAL LIST OF PEOPLE MET

Name	Position or Speciality	Official Station
D.J. B. Calverley	Hd, Storage Dept	TDRI, London Road, Slough, England
John A. Hallam	Engineer	TDRI, London Road, Slough, England
W.H. Andrews	Education	TDRI, London Road, Slough, England
Tate O'Dowd	Seed Storage	TDRI, London Road, Slough, England
L. Eriksson	Chief Project Manager	SIDA, Nakuru
David Lundberg	Chief, Agr. Division	USAID/Nairobi
Dwight Walker	Project Manager	USAID/Nairobi
John Thomas	Deputy Chief, AGR Div	USAID/Nairobi
A.D. Smith	Economist	USAID/Nairobi
Larry Van Fossen	Agr. Engineer	Previous CPC. Currently Iowa St. University, Ames, Iowa
Donald J. Wissman	DPRA Chairman of the Board	Manhattan, Kansas
Thomas R. Eyestone	DPRA Treasurer	Manhattan, Kansas
M.O. Were	Chief, Crop Production Branch	MOA, Nairobi
Kepha Mogoi	Head, Crop Protection Branch	MOA, Nairobi
Fred Lenz	DPRA Team Leader and Extension Specialist	Kisumu
J.M.O Sewe	On-farm grain storage Project Manager	Kisumu
L. Newby	DPRA Extension Specialist	Kisumu
S. McCarthy	DPRA Extension Specialist	Kakamega
G. Mbagaya	Acting Prov. Dir. of Agr.	Nyanza Province
*--Nyimbo	Prov. Extension Coordinator	" "
*--P. Muchelle	Prov. Postharvest Officer	" "
J. Gatimu	Prov.Crops Protection Off	" "
*--Odondi	D. A. O.	S. Nyanza District
*J. Godhana	District Postharvest Officer	" " "
-- Mungai	District Crops Officer	" " "

-- Mala	Location Extension Officer	Manyatta Location
*-- Odhok	D. A. O.	Kisii District
C. Ombese	District Postharvest Officer	" "
-- Osol	District Crop Officer	" "
R. Nyikal	District Farm Mgmt. Officer	" "
-- Diru	D. A. O.	Kisumu District
F.O. Lugwire	District Postharvest Officer	" "
-- Gwengi	Division Extension Officer	Muhoroni Division
G. Abiru	Location Ext. Officer	Koru Location
G. Oudia	D. A. O.	Siaya District
R.P. Okoth	District Postharvest Officer	" "
R.W. Bomett	P. D. A.	Western Province
H.P. Mwangi	Prov. Postharvest Officer	Western Province
F.O. Anditi	Prov. Extension Coordinator	Western Province
J. Maiko	Prov. Extension Supervisor	Western Province
J. Pwanali	D. A. O.	Kakamega District
S.M. Muchogu	District Postharvest Officer	Kakamega District
S. Misiko	Divisional Postharvest Officer	Lurambi Division
A. Okatch	Divisional Postharvest Office	Ikolomani Division
J.K. Kurgat	D. A. O.	Busia District
-- Kinoti	District Extension Coordinator	Busia District
-- Olang'	Acting Distr. Postharvest Officer	Busia District
F. Obat	Divisional Postharvest Officer	Samia Division
J. Kigen	Divisional Postharvest Officer	Nambale Division
-- Busaule	District Postharvest Officer	Bungoma District
-- Mwando	Divisional Postharvest Officer	Kanduyi Division

*Identifies persons in the positon, but they were represented by other officers.

ANNEX D

PROJECT EXPENDITURES TO 31 JANUARY 1987

Project expenditures are reported monthly. These expenses and related budget allocations - are summarized below. In addition, USAID committed approximately U.S. one million dollars for construction of the permanent buildings, evaluations and other costs. Their expenditures in this category have been about $450,000 U.S. The Government of Kenya (GOK) committed the equivalent of $3,900,000 U.S. mostly in salaries and program support.

Project Budget Category	Budget Allocation	Actual Expenditures as of 31 Jan 1987	Percent Spent
Long Term Staff	$3,173,000.	1,702,079.73	53
Short Term Consultants	225,000.	30,786.44	14
Training	1,326,000.	272,062.92	21
Equipment and Vehicles	1,220,000.	571,827.12	47
Test Structures	88,000.	40,994.81	47
Maize purchases	73,000.	10,915.96	15
Cribs and Platforms	675,000.	221,911.29	32
Project Total	6,800,000.	2,850,578.27	42

GRAIN LOSS ESTIMATES:

Grain loss estimates are highly variable due to:

a) inherent variation from season to season, from sub-location to sub-location and between management practices, b) inaccurate incomplete and inconsistant evaluation methods, and c) quality losses that are difficult to assess. Most assessments exclude losses to rodents and thieves and some exclude bird losses. Quality losses (nutritional value, organoleptic characteristics and the generation of toxins) are usually ignored or not assigned an economic value. For example, the 1979 DPRA study found 14% of the grain samples had a persumptive aflatoxin level of 40 ppb or more. This is twice the level permitted in feed shipped in interstate commerce in the US (20ppb), but did not influence the economic loss estimate in that study. Grain heavily infested with insects or mold is not used as human food even though it may have less than 15% dry/matter loss. It may be used for animal feed or beer manufacture but its economic value is less per unit (of weight than non-infested grain).

Even though these deficiencies exist, it is important to estimate grain loss potential and its sensitivity to environmental conditions for alternative management systems. Probable economic impact assessments are based on these estimates as are new management recommendations.

The primary sources for our estimates are the 1979 DPRA study, two reports by Giles in 1986 and second-hand information from the DeLima report. The sensitivity statements are based on this information and a basic knowledge of grain storage dynamics.

The most common causes of grain loss are insects, molds, rodents, birds, germination, spillage, mechanical damage and theft. Bird and theft losses cannot be entirely prevented, but are minimized by early harvest

and exclusion of birds and thieves from dryers and storage units. Rodent control is similar but includes traps, poisons and preditors and is greatly assisted by removal of nesting or hiding sites and other food sources in the community Mechanical damage and spillage can be minimized by careful handling.

Insect control depends primarily on temperature and the proper use of insecticides. Insect activity and reproduction is insignificant if the temperature is below 10°C or above 40°C. Between 5°C and 35°C the activity and reproduction rate doubles for each 5°C rise in temperature. Thus decreased storage temperatures are beneficial even if the temperature remains above 10°C. In theory, insects can be controlled by adjusting the gas composition in the storage facility. Either low oxygen (<1%) or high carbon dioxide (>10%) will control insects. This is not a practical control method because it requires a store that is nearly gas tight and must have either an artificial atmosphere generator or depend on insect and mold activity to continually use oxygen. Grain respiration rates are too low to even maintain the required conditions. Furthermore, in a sealed store identification and correction of storage problems are nearly impossible.

The primary mold control is reduced moisture content. Grain that is in equilibrium with air at a relative humidity below 70% will not support mold growth. At higher moisture contents mold growth and microtoxin production are possible. Decreasing temperature decreases the mold growth rate, but temperatures below 0°C are required for long term storage of high moisture grains.

As stated on figure 1, the estimated loss rates were determined in tests near Maseno, Kenya. In a region with higher relative humidity, the natural air drying rate would be reduced. This increases the time from harvest until the grain is safe from further mold growth and the time until the grain is sufficiently dry to shell and treat with an insecticide. Thus both mold and insect risks are increased, but the greatest risk is from mold growth and possible aflatoxin production. We

are not aware of any data on safe drying times for white maize. Tables for hybrid yellow dent maize (corn) probably under-estimate the safe drying time for maize. In fact, these tables would predict periodic mold problems for corn dried at the rates reported for husked maize in raised baskets or cribs.

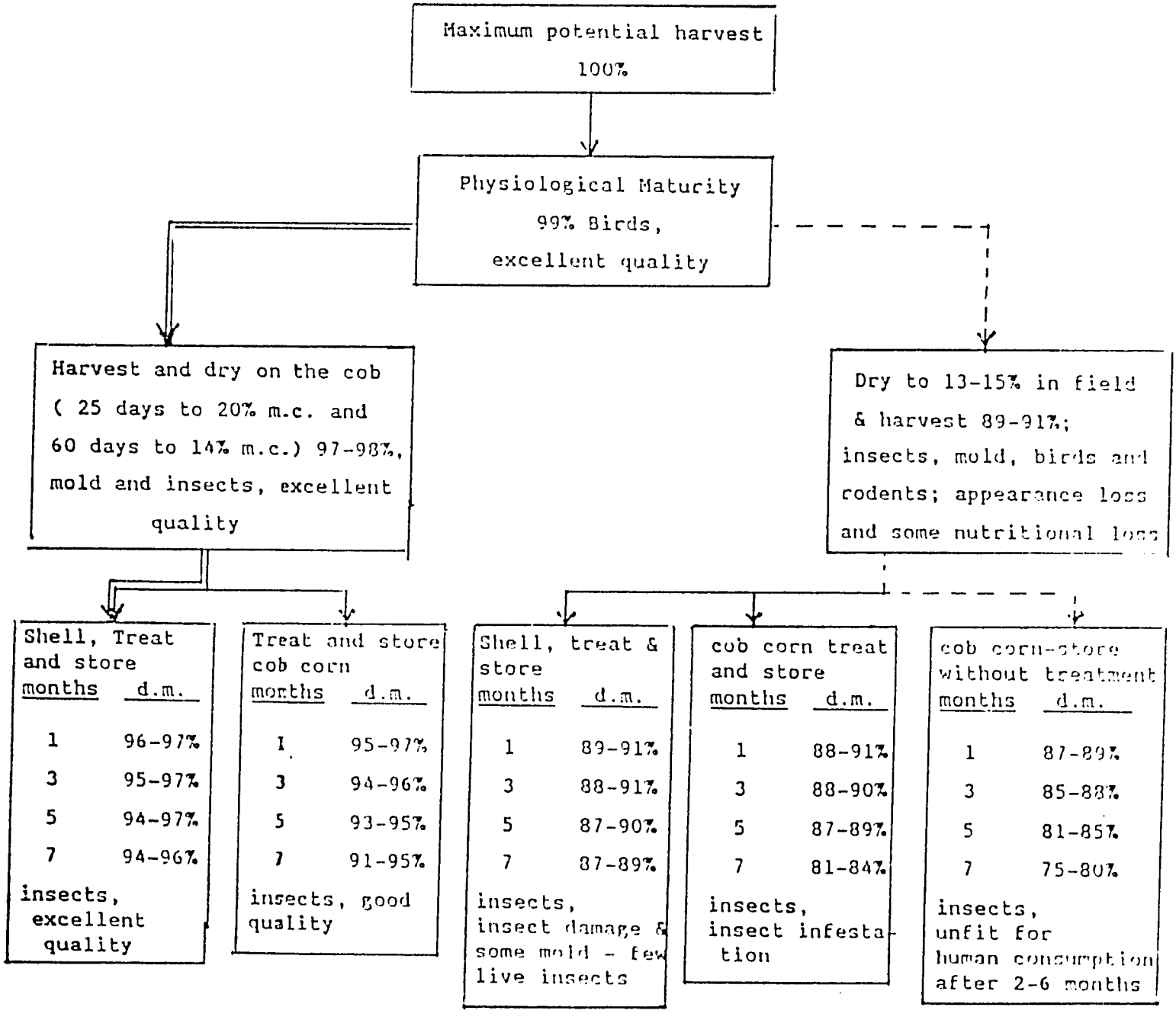
Higher temperatures slightly increase drying rates, but the greatest influence is on insect activity and mold growth rates. Safe drying times are reduced in higher temperature climates. Also the effective life of insecticides is reduced at higher temperatures or higher moisture contents. The influence of temperature and relative humidity can not be accurately estimated without isothermal equilibrium relative humidity curves for white maize.

Practices such as stooking that increase the grain drying time also increase the mold damage potential and give insects more time to reproduce. In the absence of basic maize storage data (isothermal curves and safe drying time curves), drying and storage recommendations should be tested before they are recommended in regions of higher temperatures or relative humidities. (Agro-ecological zones UM 1, LM 1, L 3 and L 4 are most likely to be difficult but high relative humidities may occur during the drying season in other zones).

The loss estimates in Fig. 1 assume that a sample of grain is harvested, and held for the specified period of time. Obviously most stored grain is gradully consumed decreasing the quantity of grain subject to loss. By assuming a use or disappearance curve and totaling the losses over the expected storage time, an average loss percent can be calculated. By using the same disappearance curve used in the Project Paper (1980), ANNEX D, Exhibit 2, we can estimate an average loss for the recommended management practices (5.1%) that can be compared with the traditional system losses (15.98%).

Figure 1, TYPICAL GRAIN LOSSES

Assuming daily average temperatures of 18-22°C from harvest to consumption, and daily average relative humidities between 60 and 70% from harvest until the maize is dried to a safe storage moisture content, typical grain losses are illustrated below. The losses are given as a percent of maximum potential dry matter (d.m.) retained. Principal loss agents and expected quality characteristics are listed for each step. Drying and storage facilities are assumed to be rodent, bird and theft proof.



traditional management practices

recommended management practices

ANNEX F

ON FARM GRAIN STORAGE PROJECT

1985-86 MOALD STAFF TRAINING PROGRAM

OFFSHORE

AREA OF OPERATIONS	TRAINING SITES	TRAINING DATES	NAME OF PARTICIPANTS	DESIGNATIONS	COMMENTS
National	Mississippi State University	January 1986	W. Moses Makunda	Agr. Officer	MS Ext. Education
	" " "	" "	Elly A. Miron	" "	" " "
	" " "	" "	Paul N. Kitonyi	" "	" " "
	University of Georgia	January 1986	Felister W. Makini	" "	MS Microbiology
	" " "	" "	Constanzo R. Mukinda	" "	MS Agr. Economics
	" " "	" "	Jasper A. Mkanya	" "	MS Agr. Engineering
	Kansas State University	June-July 1985	R.D.M. Kituyi	PDA, Nyanza Prov.	Grain Storage & Marketing
	" " "	" " "	Kepha M. Mogoi	Head, Crop Protection, Branch	" " "
	" " "	" " "	R. W. Bomett	PDA, Western Prov	" " "
	" " "	" " "	Kamau Muni	Principal, Embu Inst of Agr.	
	" " "	" " "	George O. Ogola	Principal, Bukura Inst of Agr.	" " "
Nyanza Province	TDRI Slough, G.B.	May-June 1985	Phoebe Muchalle	Agr. Officer	Certificate
Kisii District	" " "	" "	Charles Ombese	Tech. Officer	"
Kisumu District	" " "	" "	Florence O. Lugwire	Tech. Officer	"
Siaya District	" " "	" "	Richard Paul Okoth	" "	"
South Nyanza District	" " "	" "	*Zaddock Nemba	" "	"

Western Province	TDRI Slough, G.B.		May-June 1985	Henry P. Mwangi	Agr. Officer	"
Bungoma District	" " "		" "	Jane G. Ngugi	" "	"
Busia District	" " "		" "	*Philip A. Oduor	Tech. Officer	"
Kakamega District	" " "		" "	Stanley M. Machogu	Agr. Officer	
Grain Storage Project	" " "		" "	*Wilson Okenye	Lab. Tech. Officer	"
National Agricultural	" " "		" "	Jane N. Ngugi	Agr. Officer	"
Crop Protection Branch	" " "		" "	Joel M. Gatuthu	Tech. Officer	"
Rural Structures Unit	" " "		" "	Kinster M. Moi	" "	"
Rural Structures Unit	" " "		" "	Haroun R. Lwangu	" "	"
Egerton College	" " "		" "	Rebecca M. Mdugire	Med Tech Officer	"
Bukura Institute of Agr	" " "		" "	Vincent P. Maina	Tech Officer	"
Bukura Institute of Agr	" " "		" "	Owiti A. Singh	" "	"
Embu Institute of Agr	" " "		" "	Charles K. Mwangi	" "	"
Embu Institute of Agr	" " "		" "	S.K. Gitonga	" "	"

* Employed elsewhere

ON FARM GRAIN STORAGE PROJECT

1985-86 TRAINING PROGRAM

IN COUNTRY

Trainee Category	Approximate Number of People Trained						
	Nyanza Province				Western Province		
	Siaya	Kisumu	Kisii	South Nyanza	Busia	Bungoma	Kakamega
Administrative Officers	19	10	20	31	----Approximately 110 ----------		
Technical Officers	46	42	25	48	9	5	12
Technical Assistants	65	100	69	96	76	72	80
Demonstration Farmers	30	18	26	60	51	42	62
Artisans (Fundis)*	16	11	14	19	20	18	20
Number of Field Days at Demonstration Farms	13	5	1	8	---------- 60----------		
Number of People Attending Field Days	942	400	15	790	1630	780	1970
Exhibits at Agricultural Shows (Years)	1986	1984 1985 1986	1985 1986	1986(2)	1986	-	1984 1985 1986

* Two fundis from each cluster area received the initial training

Subjects covered in training sessions included harvesting, drying, treatment and storage

COST BENEFIT ANALYSIS FOR KENYAS WESTERN REGION

ANNEX G

Year	Production MT	Adoption %	Current Post Harvest Losses MT	Reduced Post Harvest Losses MT	Value of Reduced Harvest Losses US$	USAID Costs US$	Crib Construction Costs US$	GOK Costs US$	Total Costs US$	D.F	Discounted Costs US$	Discounted Benefits US$
1984	466,801.55	0.00	0.00	0.00	0.00	1,370,070.00	0.00	31,569.00	1,401,639.00	0.87	1,219,425.00	0.00
1985	478,770.83	0.00	0.00	0.00	0.00	960,758.00	4,594.17	45,049.00	1,010,401.17	0.76	767,904.89	0.00
1986	491,047.00	0.60	471.41	324.05	58,336.38	915,280.00	41,347.44	236,986.00	1,193,613.44	0.68	811,657.14	39,668.74
1987	491,046.00	6.00	4,714.04	3,240.90	583,362.65	900,000.00	16,155.40	300,000.00	1,216,155.40	0.66	802,662.56	385,019.35
1988	497,792.00	8.00	5,371.74	4,380.57	788,502.53	0.00	16,527.04	300,000.00	316,527.04	0.57	180,420.42	449,446.44
1989	504,223.00	10.00	8,067.57	5,546.45	998,361.54	0.00	8,909.56	300,000.00	308,909.56	0.50	154,454.78	499,180.77
1990	510,328.00	11.00	8,981.77	6,174.97	1,111,494.38	0.00	9,018.56	300,000.00	309,018.56	0.43	132,877.98	477,942.59
1991	515,998.00	12.00	9,907.16	6,811.17	1,226,011.25	0.00	25,380.74	300,000.00	325,380.74	0.38	123,644.68	465,884.27
1992	521,311.00	15.00	12,511.46	8,601.63	1,548,293.67	0.00	17,612.03	300,000.00	317,612.03	0.28	88,931.37	433,522.23
1993	526,420.00	17.00	14,318.62	9,844.05	1,771,929.72	0.00	9,583.00	300,000.00	309,583.00	0.25	77,395.75	442,982.43
1994	531,317.00	18.00	15,301.93	10,520.08	1,893,613.79	0.00	1,313.28	300,000.00	301,313.28	0.22	66,288.92	416,595.03
1995	535,996.00	18.00	15,436.68	10,612.72	1,910,289.74	0.00	9,677.13	300,000.00	309,677.13	0.19	58,838.65	362,955.05
1996	540,449.00	19.00	16,429.65	11,295.38	2,033,169.14	0.00	9,743.65	300,000.00	309,743.65	0.16	49,558.98	325,307.66
1997	544,670.00	20.00	17,429.44	11,982.74	2,156,893.20	0.00	18,352.90	300,000.00	318,352.90	0.14	44,569.41	301,965.05
1998	548,654.00	22.00	19,312.62	13,277.43	2,389,936.82	0.00	9,896.54	300,000.00	309,896.54	0.12	37,187.59	286.792.42
1999	552,394.00	23.00	20,328.10	13,975.57	2,515,602.28	0.00	9,919.99	300,000.00	309,919.99	0.11	34,091.20	276,716.25
2000	555,885.00	24.00	21,345.98	14,675.36	2,641,565.52	0.00	9,929.46	300,000.00	309,929.46	0.09	27,893.65	237,740.90
2001	559,121.00	25.00	22,364.84	15,375.83	2,767,648.95	0.00	1,860,727.73	300,000.00	2,160,727.73	0.08	172,858.22	221,411.92
Total	9,372,223.38		213,293.02	146,638.95	26,395,011.56	4,146,108.00	2,078,688.63	4,813,604.00	11,038,400.63	6.49	4,850,662.12	5,623,130.49

Benefit-cost ratio.....1.6

Break-even adoption rate.....10 Percent

D.F - Discount factor.....15 Percent

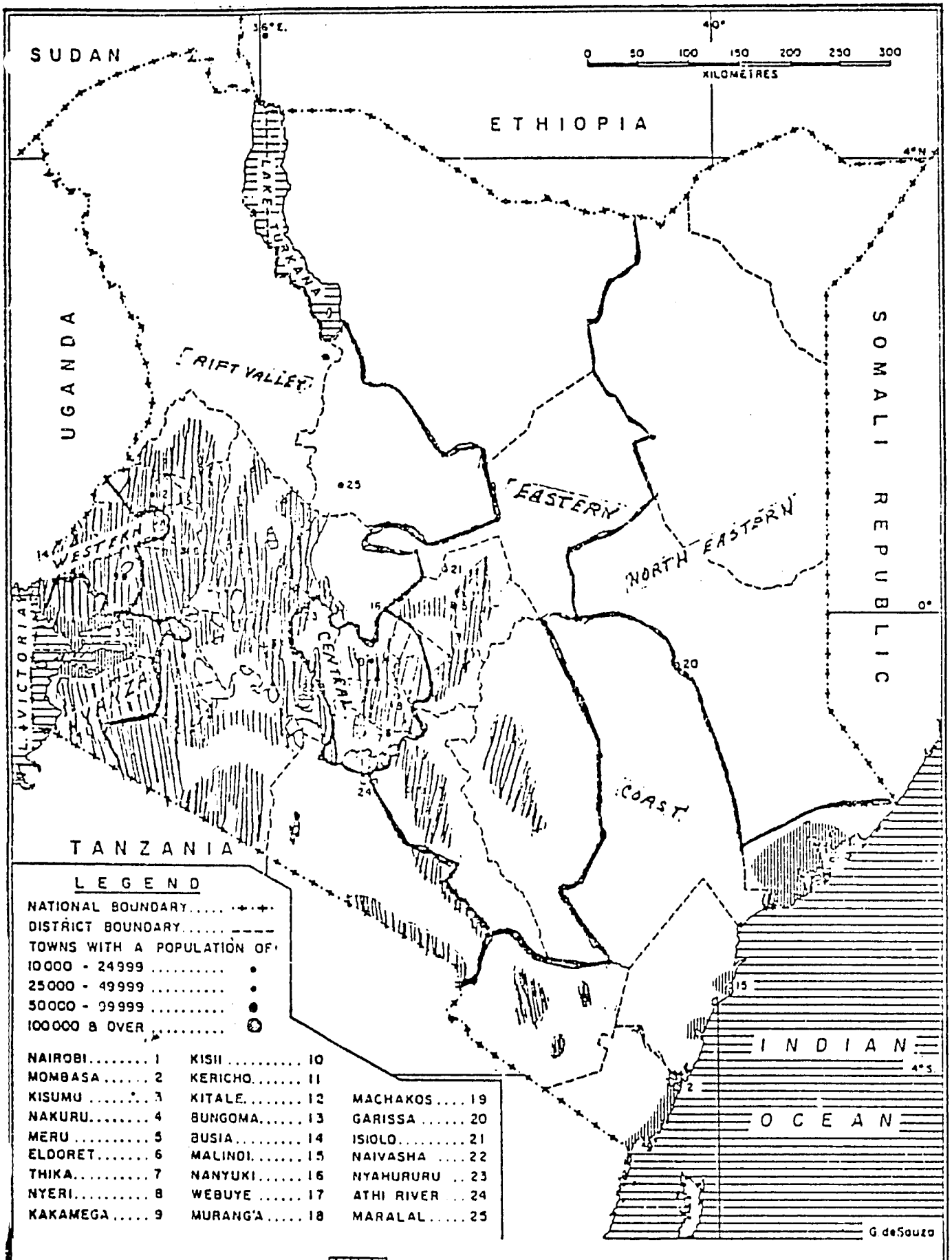
Notes: In 1984 and 1985 there was hardly any adoption of the new storage technology.

Between 1987 and 2001 adoption is assumed to increase to 25 percent.

Current harvest losses are estimated at 16 percent and reduced losses at 11 percent. A shadow price of US $180 was used in estimating grain values.

Costs of crib construction are estimated by calculating the number of cribs required to store additional grain saved after adoption of new technology and multiplying the number of cribs with US $63.79 which is the cost of platform-two-section crib.

It was extremely difficult to estimate GOK's cost input into the project especially overhead costs. However, an estimate of US $300,000 has been used in projecting future costs. Most of these costs will be used mainly in extension. USAID costs include $450,000 used for construction of staff houses and laboratory and these costs are included in 1984 costs.



Maize Growing areas

Reference: Farm Management Handbook of Kenya (Vol. II)