The evaluation of losses in maize stored on a selection of small farms in Zambia with particular reference to the development of methodology (G109)

Tropical Products Institute

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Foreword

The main intentions of this Project were to investigate and evaluate various methods that could be used to assess the physical storage losses in grain incurred by small scale farmers, and to apply the losses determined by appropriate methodologies to an evaluation of the costs and benefits of a simple improved storage technique.

It was not the intention that the losses discovered during the investigation and evaluation of methodologies should be interpreted as being typical of Zambia as a whole, nor of any particular region. Thus a recognised sampling technique was not used to select farmers from whom the grain samples required to carry out the methodology assessment were drawn; nor were sampling techniques, which have been well documented elsewhere, examined. Rather the farmers were selected for their accessibility and responsiveness, provided that the extension staff of the Ministry of Rural Development considered them to be fairly typical small scale farmers.

For the work on evaluation of the costs and benefits of a simple improved storage technique, it was originally intended to include data obtained from farmers using both traditional and the improved methods. However, there were insufficient farmers found who had adopted all the recommendations, so the cost/benefit analysis was based entirely on the results obtained from the experimental stores built by the Project.

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ACKNOWLEDGEMENTS

We are indebted to the Government and people of Zambia for permission to undertake the project and for the cooperation and courtesy shown to us during our stay. We wish especially to thank the Deputy Director of Agriculture (Research), the Chief Agricultural Research Officer, staff of the Food Conservation and Storage Unit (FCSU), and staff of the Workshops, Mt. Makulu for the provision of facilities and assistance; also those members of the agricultural extension staff in Lusaka Rural, Mazabuka and Monze districts who guided and interpreted for us during the surveys and sampling programme. The assistance of Mr J. M. A. Herdman and Mrs C. N. Seath of the British High Commission was much appreciated.

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The evaluation of losses in maize stored on a selection of small farms in Zambia with particular reference to the development of methodology

SUMMARY

The terms of reference for this project were: (1) to develop a satisfactory methodology to evaluate the extent of losses; (2) to establish reasonably reliable cost-benefit relationships for a simple improved farm storage technique; and (3) to recommend whether a longer term project should be undertaken over a wider area to evaluate cost-benefit relationships of improved storage techniques for the purpose of planning development programmes.

Following these criteria the report makes a detailed study of various methods of assessing losses. These methods are then applied to maize stored by small farmers in selected areas of Zambia and an evaluation made of the costs and benefits to these farmers of adopting an improved storage technique.

The biological approach to loss depends on the definition of loss. Losses of quantity, quality and seed are discussed. The problem is to obtain a measurement that can be translated into economic terms. Survey techniques and the taking of grain samples are discussed. Various ways of using such samples to estimate loss are practised and may be divided into volumetric, gravimetric and indirect methods. A description of the underlying principles of each of these is given.

The economist's approach to 'loss' is to study the economic consequences which flow from the diminution in the quantity and quality of a product while it is in store. Evaluation of these consequences may be made from the point of view of the person experiencing the loss or from that of the country as a whole.

The fundamental principle underlying evaluation is an assessment of the opportunity, or intended usage, which is foregone due to the occurrence of loss and the sacrifice or cost borne as a result.

When valuing losses from the farmer's viewpoint this principle may be applied to his four main uses of stored foodstuffs — food, sale, feeding to animals and seed for sowing his next year's crop. When losses are assessed from the social viewpoint the value to be attributed may be based on the price at which the country traded (or could have traded) the particular produce.

Measurable losses may be:

1. Quantitative or qualitative
The cost borne due to qualitative loss may be assessed by using an appropriate grading system and related price differentials.

2. Direct or indirect
Direct losses are those resulting directly from damage occurring in a particular year. Indirect losses or costs are borne due to the anticipation of what losses will occur.

3. Values — gross or net
Damaged produce may have an alternative use. In an assessment of net loss its value in this outlet is taken into account.

Some losses which have an economic significance are not easily susceptible to evaluation. Nutritional losses which may impede a farmer's work, or result in extra medical facilities expenditure, are an example.

The research programme commenced with a selection of areas. Selection was made by touring those accessible from the project's base. Two areas were selected; one, Chivuna, in which maize stored on the cob with husks attached was typical; the other, Chalimbana, where shelled maize storage was typical. A description of the project areas, their climate and the stores is given with a description of the system of maize cropping used.

A questionnaire survey was conducted among a number of farmers within the two areas chosen. Information collected included background economic and social data relating to individual farmers and information on their stores and storage practices. Other sections of the questionnaire covered losses and farmers' usage of their stored maize.

At the end of the storage period a second questionnaire was conducted among the selected farmers to obtain data required for the economic evaluation of losses.

A third, shorter, questionnaire survey was conducted in areas around those selected to test whether the storage pattern of the farmers chosen differed from that of other farmers in the vicinity. The findings showed that no marked difference existed.

The results of the questionnaire surveys taken as a whole revealed that most farmers had received a little primary education. In the area where shelled grain was stored, Chalimbana, half the farmers had outside jobs in addition to farming. This was probably due to the proximity of the capital city, Lusaka. In Chivuna few outside jobs were available and only a minority of farmers did additional work off their farms.

The farmers in Chalimbana had come from different areas and had introduced the idea of shelled grain storage, whereas those in Chivuna were farming in their traditional locality.

In both areas maize was the main crop, with groundnuts the next most important. Maize was grown mainly to provide food for the family, any surplus being sold immediately after harvest, nearly always to the government. This was normally of the highest grade. The most common maize variety, grown by 70% of the farmers in Chivuna, was the hybrid SR52. However, 50% of farmers in Chivuna grew, either solely or additionally, a local type based on the variety Hickory King and 25% grew an undefined local variety. 75% of farmers growing both SR52 and another variety sold all their SR52 because of its poor storage qualities and it was found that farmers were particularly aware of the problems of storing hybrid maize and its higher susceptibility to insect attack. In Chalimbana less SR52 was grown than in Chivuna but the amount was increasing. In both areas the major cause of loss mentioned by farmers was insects. Farmers' estimates of the size of their losses were low, mainly below 5%, but some interpreter bias appeared with this question. Farmers also became more loss conscious when they knew someone thought their losses important enough to investigate; this could have affected the estimates they gave. Damaged maize was used for feeding animals or making beer.

Over 75% of the farmers storing shelled grain used an insecticide although only one farmer used the recommended malathion treatment, the others using mainly DDT or BHC. Of the farmers storing cob maize 66% used an insecticide, usually BHC. Analysis of residues on the cob maize showed negligible carry over of the insecticides to the grain after husk removal and shelling. In the case of one farmer using DDT and BHC on shelled maize high residues occurred throughout the season but the insects still caused considerable damage.

The first questionnaire survey conducted was used to select farmers for a programme of sampling. This was undertaken fortnightly throughout the storage period. Maize was removed from the stores and analysed on each sampling occasion to determine the cause and extent of loss. The major cause was infestation by insects, the important species being *Sitotroga cerealella* (Oliv.), *Sitophilus zeamais* Mots. and *Tribolium castaneum* (Herbst.). *S. cerealella* infestation was considerably reduced by storage of shelled grain but there was an unexpectedly high level of damaged grain at the bottom of such stores at the end of the season. Losses caused by moulds and rodents were negligible. Loss of seed was also negligible because of the prevailing climatic conditions, short storage period, and selection by farmers.

Simulation of farmer storage was carried out at the project's base at Mt. Makulu, using stores similar in construction to those of the farmers whose stores were sampled. These were filled with maize obtained from farmers in the areas under study. Cobs were stored both with and without husks, also shelled maize, both untreated and treated with the recommended dosage of malathion (100g of 1% malathion dust per 90 kg maize). Samples were taken at regular intervals to simulate the way in which farmers removed grain from their stores, and sub-samples removed for analysis. Small weighed samples were also included in these stores to assist in the assessment of losses.

The moisture content of the maize rose from approximately 10% at commencement of storage, to 14—15% maximum during the rainy season, falling a little after the end of the rains.

Termites attacked two of the muddied simulation stores. In practice this rarely happens with farmers' stores, which are not normally made of susceptible timber.

Losses in quality were estimated, using a grading system based on local marketing acceptance standards in conjunction with the farmers' subjective appraisal. The quality acceptable to the farmers became lower as their grain stocks diminished. Quality was maintained in shelled grain stored in the recommended way in the simulation stores. However, where farmers who stored cobs deliberately selected those with tight husks this maize maintained its quality nearly as well. Maize stored on the cob with the husk removed suffered the worst quality deterioration.

Losses in quantity in the simulation stores were obtained by weighing removals and deducting the total of these from the weight of maize entering the store. For purposes of comparison losses were estimated on a dry weight basis. Weight losses were 1% or less in the treated shelled grain stores, (except where termite damage occurred), 3% in the untreated shelled grain stores and 13% in the stores containing unselected cobs with husks. Cobs without husks suffered a loss of 9% in store. However in this last case an additional loss of probably over 5% had already taken place between harvest and placing in store; in the other cases the loss before commencement of storage was insignificant. Estimation of losses in cob storage was complicated by conversion into weight of shelled grain.

In order to test the validity of the various techniques of assessing losses these were applied to the samples of maize taken from the simulation stores and the results compared with those obtained by weighing.

Analysis of the small weighed samples within these stores demonstrated that time in store was important for shelled grain, a loss of 0.054% per day being calculated.

The weight of a standard volume of grain throughout the storage period compared with that at the time of storage commenced was a reasonably accurate and practical method of assessing loss, although allowance had to be made for maize variety, dust admixture and moisture content changes. This estimate was improved by including data on percentage damaged grain and time in store in the regression analysis. However, collection of such data was time-consuming.

The weight of a standard number of grains (100) of a sample was not found to give a useful estimation of loss. A formula comparing weights of undamaged grains and found suitable at intermediate levels of damage was inaccurate at low levels. It would be useful for estimation of losses from a single sample. Number of insects sieved off or bred out, and percentage by weight of dust recovered from samples were found difficult to use in practice and were not good indicators of weight loss.

Percentage damaged grain is commonly used to assess loss but ceases to be accurate at high damage levels. In the simulation shelled grain stores 1% damage was found to be equivalent to 0.12% weight loss. Because of the localisation of damage in cobs with husks the relationship between percentage weight loss and damage was different, percentage weight loss being equal to 0.22 times the percentage damaged grain plus 0.15% for each week in store.

Losses of the maize in farmers' cob stores increased as the season progressed, and at the end of the storage period were 8—10%. However, when the reduction in stocks throughout the season is taken into account losses averaged 2—5% over the storage period as a whole. The low magnitude of these losses demonstrates the benefit of cob selection which was practised by the selected farmers. Those farmers storing greater quantities of maize for longer periods suffered the highest percentage losses. Due to a poor harvest only one of the selected farmers in Chalimbana was able to store shelled grain throughout the storage season. He stored a hybrid variety and suffered a loss of approximately 6%.

It is suggested that the analytical methods employed in estimating losses be applied first to maize under different climatic and storage environments and then to other stored commodities.

In evaluating losses of the selected farmers considerable use was made of data on their pattern of maize consumption collected during sampling visits. Each farmer was asked about the quantity of maize he had taken from his store since the last visit and about the ways in which this had been utilised.

Farmers were aware that their maize suffered damage and it was decided that the most realistic assumption to make in evaluating their weight losses was that this loss would be borne by that usage (or usages) of a farmer's maize which was lowest in his order of priorities. This principle was applied to each farmer in turn. The values obtained for Chivuna farmers ranged from K0.36 for a farmer whose one store was empty by the beginning of February to K12.33 for a farmer with four stores whose maize lasted throughout the season. The loss of the one farmer in Chalimbana storing grain throughout the storage season was valued at K1.78. Weight losses were also assessed using the average price at which farmers purchased maize. The values obtained were similar to those found by the more detailed methods due to the small range at which maize transactions took place and the absence of significant differentials in the prices of maize bought for different purposes.

Quality losses were assessed using the grading system applied to sales of maize to NAMBoard.* Individual withdrawals of maize from the store were priced, valued and summed to give the total value removed. The value of the loss was obtained by deducting this amount from what it would have been if all withdrawals had been of the top grade. Values obtained for individual stores varied between K0.15 and K15.51; expressed as a percentage of the maximum possible value of the maize concerned losses ranged between 0.7% and 24.2%.

Indirect losses were valued at the amount which farmers spent on their insecticide.

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*National Agricultural Marketing Board of Zambia

The total value of losses experienced by farmers storing cobs (ie quantitative and qualitative and indirect) varied between K2.16 and K36.25 with a mean of K10.00 and a median of K6.55. Total losses per farmer per store ranged between K2.16 and K9.06 (mean K5.38, median K3.56). The loss borne by the farmer in Chalimbana with one store was valued at K20.05. With one exception quality losses suffered by farmers were greater than those suffered due to loss of weight.

Weight losses from the social viewpoint were assessed by using the average border 'price' obtained for Zambia's exports of maize adjusted, as far as possible, for the transport, handling and other costs reflected in this value. Quality and indirect losses were evaluated using a similar method to that employed for individual farmers.

The total value of the loss borne by the country as a result of the damage experienced by the eight farmers in both Chivuna and Chalimbana whose losses were evaluated was put at K95.05.

It should be stressed that all these values are based on the findings of just one storage season and are only valid for the farmers chosen, not for the small farmer in Zambia as a whole.

The costs and benefits for the small farmer of storing his maize in the way recommended by the Ministry of Rural Development are assessed.

These recommendations are:

(a) storage should be in grain form,

(b) stores should be muddied both inside and out,

(c) insecticide (malathion) should be added when storage takes place.

Since these recommendations are more a variation of existing techniques than a change to entirely new ones it was decided to use a marginal approach to their evaluation and to compare the extra costs with the extra benefits of the change. The two major costs for a farmer of adopting the recommended system of storage are his outlay on insecticide and the value of the time spent in shelling his maize, mudding his store and applying the insecticide.

Information on the time taken for mudding and applying insecticide was obtained from studying construction of the simulation stores at Mt. Makulu and recording the time taken to apply malathion in the shelled grain stores; that for shelling was obtained from a German study (Gelleschaft für Regionale Strukturentwicklung, 1971) of farmers in Southern Province.

The rate at which to cost time was based on information obtained from the questionnaires on work undertaken by farmers and on existing statutory regulations for work of the relevant type. Consideration was given to the availability of employment, whether the farmer was free to do it, possible preference for leisure and the fact that shelling maize is often undertaken, at least partly, by a farmer's wife and children. Attention to such factors resulted in a range of costs depending on the assumptions made. If a farmer stored the quantity of cobs (10 bags) put into the Mt. Makulu stores his costs, under what was considered the most likely assumptions, would be K2.80. In the case of untreated grain (7 bags) in a muddied store the comparable figure would be K0.80.

The adoption of the recommended system of storage would also involve costs that are not easily valued such as the time spent in learning the new method and the risk of making mistakes.

The quantitative benefit of adopting the improved method of storage was assessed by using the data obtained on physical losses from maize stored by different methods at Mt. Makulu. It was taken to be represented by the additional quantity of maize that would have been available if, in all cases, storage had been by the improved method. This amount was found by applying the percentage weight loss which took place in maize stored in the improved way to the quantity of maize in the other stores, and then deducting this from the loss which actually occurred. The additional maize that would be available to a farmer currently storing cobs with husks attached was 39 kg and for one storing grain 8 kg. These amounts were priced at the average rate at which purchases were made by the selected farmers since, following a poor harvest, purchases were more common than sales during the storage period. The values obtained by this means were K1.73 and K0.36.

The qualitative benefits for a farmer adopting the recommended method of storage were assessed by applying the NAMBoard grading system to individual withdrawals from each store. These were priced and a total value obtained. For inter-store comparison these values were reduced to the common unit of a 90 kg bag which may be visualised as containing maize of various grades in proportion to the amount each grade formed of the total maize removed from the store, and with each proportion being valued at its respective price. The additional value of a representative bag taken from maize stored in the recommended way was K0.67 per 90 kg when compared with maize stored in cob form with husks and K0.22 per 90 kg when compared with maize stored as untreated grain. These premiums were used to obtain the qualitative benefits of K2.68 for a farmer changing from cob storage and K1.54 for one changing from untreated grain, on the basis of the amounts stored at Mt. Makulu of 10 bags (4 bags of grain equivalent) of cobs and 7 bags of grain.

The conclusion reached from comparing costs with benefits was that, except when the most unfavourable assumptions were made, benefits were the greater. The most likely ratio was 1:1.6 for a farmer currently storing cobs with husks and 1:2.4 for farmer currently storing grain. This analysis is based on the losses sustained in the simulation stores.

Apart from the nutritional benefit obtained by farmers using the recommended method others not included in the evaluation are: greater security of knowing that their maize would be in good condition, reduced infestation of crops from insects flying from the store and a wider use of SR52 maize.

The costs and benefits to Zambia as a whole of an improvement in storage are discussed but, on account of the small and possibly unrepresentative nature of the sample of farmers, not quantified.

To enable African countries to plan development programmes in the field of improved storage it is recommended that cost-benefit analysis be applied to data obtained from the area where the improved technique is proposed, since the results derived in one situation are unlikely to be transferable to another.

Recommendations are also given on the carrying out of research projects designed to obtain the necessary background technical and local economic data required.

RESUME

L'estimation des pertes au cours du stockage du maïs faites sur un choix de petites fermes en Zambie, en se référant particulièrement au développement de la méthodologie

Les buts de ce projet sont: (1) développer une méthodologie satisfaisante pour estimer l'importance des pertes; (2) établir des relations coût-profit raisonnablement sûres pour une technique simple améliorée de stockage à la ferme; (3) conseiller su un project à plus long terme doit être entrepris sur une plus grande échelle pour évaluer les relations coût-profit des techniques améliorées de stockage en vue de planifier des programmes de développement.

En suivant ces critères, ce rapport étudie en détail différentes méthodes d'estimation des pertes. Ces méthodes sont alors appliquées au maïs stocké par des petits fermiers dans des régions choisies de Zambie; une estimation des coûts et des profits est faite pour ces fermiers adoptant une technique améliorée de stockage.

L'approche biologique des pertes dépend de la définition de celles-ci. Les pertes en quantité, en qualité et en semences sont étudiées. Le problème est d'obtenir une mesure qui puisse être traduite en termes économiques. Des techniques de surveillance et le prélèvement des échantillons de grains sont discutés. Différents modes d'utilisation de ces échantillons pour estimer les pertes sont pratiqués et peuvent être divisés en méthodes volumétriques, gravimétriques et indirectes. Une description des principes fondamentaux de chacune de ces méthodes est présentée.

Pour l'économiste, l'approche des pertes, c'est l'étude des conséquences économiques découlant de la diminution de la quantité et de la qualité d'un produit pendant son stockage. L'estimation de ces conséquences peut être faite du point de vue de la personne subissant ces pertes ou du point de vue du pays dans son ensemble.

Le principe fondamental à la base de l'estimation est une évaluation de l'opportunité, ou de l'usage projeté, qui est perdu á cause de la production de pertes et du sacrifice oû du cout supporté qui en résultent.

Quand les pertes sont estimées du point de vue du fermier, ce principe peut être appliqué à ses quatre utilisations principales de denrées stockées: alimentation, vente, alimentation du bétail et graines en vue de l'ensemencement de sa récolte de l'année suivante. Quand les pertes sont estimées d'un point de vue sociologique, la valeur que l'on doit leur attribuer peut être basée sur le prix auquel le pays a négocié (ou aurait pu négocier) ce produit particulier.

Les pertes mesurables peuvent être:

1. Quantitatives ou qualitatives
Le coût à supporter du fait de pertes qualitatives peut être estimé en utilisant un système de classification approprié et des différences de prix reliées à cette classification.

2. Directes ou indirectes
Les pertes directes sont celles résultant directement des dégâts qui se produisent dans une année particulière. Les pertes ou les coûts indirects sont supportés pour prévenir les pertes qui se produiraient.

3. Valeurs, brutes ou nettes
Le produit endommagé peut avoir une autre utilisation que celle prévue. Dans une estimation de pertes nettes, sa valeur pour ce débouché doit être prise en compte.

Certaines pertes qui ont une importance économique ne sont pas facilement accessibles à l'estimation. Des pertes nutritionnelles qui peuvent gêner le travail du fermier, ou une conséquence dans des dépenses supplémentaires en frais aboutir à médicaux en sont un exemple.

Le programme de recherches commence par un choix des régions. Celui-ci est effectué en faisant le tour des régions accessibles. Deux régions sont choisies; l'une, Chivuna, dans laquelle la façon de stocker le maïs en épi avec son enveloppe est typique; l'autre, Chalimbana où le stockage du maïs égrené est typique. Une description des régions concernées par le projet, de leurs conditions climatiques et de leurs conditions de stockage est effectuée de même qu'une description du système de récolte du maïs utilisé.

Une enquête est menée parmi de nombreux fermiers à l'intérieur des deux régions choisies. Les renseignements recueillis comprennent les données de base économiques et sociologiques relatives à chacun des fermiers et des informations sur leurs silos et sur leurs pratiques de stockage. D'autres chapitres du questionnaire utilisé concernent les pertes et l'usage que font les fermiers de leur maïs stocké.

A la fin de la période de stockage, une seconde enquête est menée parmi les fermiers choisis pour obtenir les données nécessaires à l'estimation économique des pertes.

Une troisième enquête, plus courte, est conduite dans les régions entourant celles choisies pour examiner si les conditions de stockage des fermiers choisis diffèrent de celles utilisées par les fermiers voisins. Il est mis en évidence qu'il n'existe pas de différences notables.

Les résultats des enquêtes, pris dans leur ensemble, révèlent que la plupart des fermiers ont reçu un petit enseignement primaire. Dans la région où les grains égrenés sont stockés, c'est à dire dans la région de Chalimbana, la moitié des fermiers ont, en plus de leur métier de fermier, des occupations extérieures. Celles-ci sont probablement dûes à la proximité de la capitale, Lusaka. A Chivuna, peu d'occupations extérieures sont offertes et, une minorité seulement des fermiers accomplissent un travail supplémentaire á celui de leur ferme.

A Chalimbana, les fermiers proviennent de régions différentes et ont introduit l'idée du stockage du grain égrené, alors qu'à Chivuna, les fermiers travaillent dans leur région traditionnelle.

Dans les deux régions, le maïs est la culture principale, l'arachide étant ensuite la seconde culture en importance. Le maïs est principalement cultivé pour alimenter la famille, l'excédent étant vendu immédiatement après la récolte, presque toujours au Gouvernement. Celui-ci est habituellement de qualité supérieure. La variété de maïs la plus commune, cultivée par 70% des fermiers à Chivuna, est l'hybride SR 52. Toutefois, 50% des fermiers à Chivuna cultivent, soit uniquement, soit en plus, un type local basé sur la variété Hickory King, et 25% cultivent une variété locale non définie. 75% des fermiers cultivant à la fois le SR 52 et une autre variété vendent tout leur SR 52 à cause de ses faibles qualités après stockage, et il s'avère que les fermiers sont particulièrement avertis des problèmes que pose le stockage du maïs hybride et de la sensibilité plus grande de ce dernier à l'attaque des insectes. A Chalimbana, on cultive moins de SR 52 qu'à Chivuna, mais la quantité de cet hybride est en augmentation. Dans les deux régions, la cause majeure de pertes, mentionnée par les fermiers, est les insectes. Les estimations des fermiers de l'importance de leurs pertes sont faibles, en général en dessous de 5%, mais ces estimations semblent être sujettes à caution. Les fermiers deviennent également plus conscients de leurs pertes quand ils savent que quelqu'un pense que leurs pertes sont suffisamment importantes pour qu'elles doivent être étudiées; ceci peut affecter les estimations qu'ils donnent. Le maïs ambîmé est utilisé pour nourrir les animaux ou pour faire de la bière.

Plus de 75% des fermiers stockant les grains égrenés utilisent un insecticide, bien qu'un seul fermier utilise le traitement recommandé au malathion, les autres utilisant principalement le DDT ou le BHC. Parmi les fermiers stockant le maïs en épi, 66% utilisent un insecticide, habituellement le BHC. L'analyse des résidus sur le maïs en épi montre un report négligeable des insecticides sur les grains après élimination de l'enveloppe et égrenage. Dans le cas d'un fermier utilisant le DDT et le BHC sur du maïs égrené, on trouve pendant toute la saison des résidus élevés, mais les insectes provoquent encore des dégâts considérables.

La première enquête ménée est utilisée pour choisir des fermiers en vue d'un programme d'échantillonnage. Celui-ci est entrepris bimensuellement pendant toute la période de stockage. Du maïs est enlevé des silos, et chaque échantillon est analysé pour déterminer la cause et l'importance des pertes. La cause la plus importante est l'attaque par les insectes, les espèces importantes étant *Sitotroga cerealella* (Oliv.), *Sitophilus zeamais* Mots et *Tribolium castaneum* (Herbst). L'attaque par *S. cerealella* est considérablement réduite par stockage du grain égrené, mais il y a un taux élevé inattendu de grains endommagés au fond des silos à la fin de la saison. Les pertes causées par les moisissures et les rongeurs sont négligeables. Les pertes en semences sont également négligeables à cause des conditions climatiques prédominantes, de la courte période de stockage et de la sélection par les fermiers.

La simulation du stockage par le fermier est effectuée au siège du project, à Mt Makulu, en utilisant des silos semblables dans leur construction à ceux des fermiers dont les silos ont été échantillonnés. Ces silos sont remplis avec du maïs obtenu chez les fermiers habitant les régions soumises à l'étude. Les épis sont stockés avec et sans enveloppe, de même que le maïs égrené, avec et sans traitement par la dose recommandée de malathion (100 g de poudre à l% de malathion pour 90 kg de maïs). Des échantillons sont prélevés à intervalles réguliers pour simuler la manière avec laquelle les fermiers enlèvent le grain de leurs silos, et des sous-échantillons sont prélevés pour l'analyse. Des petits échantillons pesés sont également enfermés dans ces silos pour aider à l'estimation des pertes.

La teneur du maïs en humidité monte d'environ 10% au début du stockage jusqu'à 14—15% au cours de la saison pluvieuse, puis retombe un peu après la fin des pluies.

Des termites attaquent deux des silos de simulation recouverts de terre. Dans la pratique, cela arrive rarement dans les silos des fermiers qui ne sont pas habituellement fabriqués en matériau sensible.

Les pertes de qualité sont estimées en utilisant un système de classification basé sur des standards d'acceptation marchande locale de même que sur l'appréciation subjective des fermiers. La qualité acceptable par les fermiers devient de plus en plus faible au fur et à mesure que leurs stocks en grains diminuent. La qualité est maintenue dans les grains égrenés stockés de la façon recommandée dans les silos de simulation. Toutefois, là où les fermiers qui stockent des épis choisissent délibèrément ceux ayant des enveloppes hermétiques, ce maïs maintient sa qualité presqu'aussi bien. Le maïs stocké en épi, l'enveloppe de l'épi ayant été retirée, subit la plus grande baisse de qualité.

Les pertes en quantité dans les silos de simulation sont obtenues en pesant tout ce qu'on enlève et en déduisant le poids obtenu du poids de maïs entrant dans le silo.

En vue d'effectuer des compaisons de pertes, les estimations sont faites sur la base de la matière sèche. Les pertes de poids sont de 1% ou moins dans les silos de grains égrenés traités (excepté pour ceux endommagés par les termites), de 3% dans les silos de grains égrenés non traités, et de 13% dans les silos contenant des épis avec enveloppes non choisis. Les épis sans enveloppe subissent une perte de 9% au stockage. Toutefois, dans ce dernier cas, une perte supplémentaire probablement supérieure à 5% s'est déjà produite entre la récolte et la mise dans le silo; dans les autres cas, la perte avant le début du stockage n'est pas significative. L'estimation des pertes dans le stockage du maïs en épi se complique par le fait que l'on doit effectuer la transformation en grains égrenés.

En vue de tester la validité des différentes techniques d'estimation des pertes, celles-ci sont appliquées aux échantillons de maïs pris à partir des silos de simulation et les résultats sont comparés à ceux obtenus par pesée.

L'analyse des petits échantillons pesés à l'intérieur de ces silos démontre que le facteur temps de séjour dans le silo est important pour le grain égrené, une perte de 0,054% par jour étant calculée.

Le poids d'un volume standard de grains tout au long de la période de stockage, comparé à celui du même volume au début du stockage, est une méthode raisonnablement précise et pratique d'estimation des pertes, bien qu'il faille tenir compte de la variété du maïs, de l'addition de poussières et des variations de la teneur en humidité. Cette estimation est amélioréé en incorporant dans l'analyse de régression des données sur le pourcentage de grains endommagés et sur la durée du séjour dans le silo. Cependant, le rassemblement de ces données demande du temps.

Le poids d'un nombre standard de grains (100) d'un échantillon ne semble pas donner une estimation utile des pertes. On démontre qu'une formule comparant les poids des grains endommagés et non endommagés convient pour des taux moyens d'endommagement, mais est imprécise pour les faibles taux. Il serait utile pour l'estimation des pertes à partir d'un simple échantillon. Le nombre d'insectes séparés, et le pourcentage en poids de poussière récupérée à partir des échantillons sont trouvés difficiles à utiliser dans la pratique et ne sont pas de bons indicateurs des pertes de poids.

Le pourcentage de grains endommagés est communément utilisé pour estimer les pertes, mais cesse d'être précis aux taux élevés d'endommagement. Dans les silos de simulation de grains égrenés, on met en évidence que 1% de grains endommagés est équivalent à 0,12% de perte de poids. A cause de la localisation des dégâts dans les épis munis de leurs enveloppes, la relation entre les pourcentages de pertes de poids et d'endommagement est différente, le pourcentage de pertes de poids étant égal à 0,22 fois le pourcentage de grains endommagés plus 0,15% pour chaque semaine passée dans le silo.

Les pertes de maïs dans les silos des fermiers contenant des épis augmentent au fur et à mesure que la saison s'écoule, et, à la fin de la période de stockage, elles sont de 8—10%. Toutefois, quand la réduction des stocks tout au long de la saison est prise en compte, les pertes atteignent en moyenne 2 à 5% pour toute la période de stockage. La faible importance de ces pertes démontre le bénéfice de la sélection des épis qui est pratiquée par les fermiers choisis. Les fermiers qui stockent de plus grandes quantités de maïs pendant des périodes plus longues, subissent les pourcentages de pertes les plus élevés. Du fait d'une faible récolte, seul, un des fermiers choisis à Chalimbana put stocker des grains égrenés pendant toute la saison de stockage. Il stocka une variété hybride et subit des pertes d'environ 6%.

Il est proposé que les méthodes analytiques employées dans l'estimation des pertes soit d'abord appliquées au maïs dans des environnements différents de climat et de stockage, puis à d'autres denrées stockées.

Dans l'estimation des pertes des fermiers choisis, on utilise beaucoup les données collectées au cours des visites effectuées pour l'échantillonnage et concernant le profil de leur consommation de maïs. On demande à chaque fermier la quantité de maïs qu'il a prélevée de son silo depuis la dernière visite et la façon dont cette quantité a été utilisée.

Les fermiers sont avisés que leur maïs subit des dégâts et il est décidé que l'hypothèse la plus réalisete à faire pour estimer les pertes de poids est que ces pertes soient supportées par l'usage (ou les usages) d'un maïs de fermier qui est le plus faibles dans son ordre de priorité. Ce principe est appliqué à chaque fermier tour à tour. Les valeurs obtenues pour les fermiers de Chivuna vont de 0,36 K pour un fermier dont un silo est vide au début de Février à 12,33 K pour un fermier ayant quatre silos conservant leur maïs pendant toute la saison. La perte d'un fermier à Chalimbana, conservant du grain pendant toute la saison de stockage, est évaluée à 1,78 K. Les pertes de poids sont aussi estimées en utilisant le prix moyen auquel le fermier achète le maïs. Les valuers obtenues sont semblables à celles trouvées par les méthodes plus détaillées du fait de la faible importance des transactions de maïs et de l'absence de différences significatives dans les prix des maïs achetés pour des usages différents.

Les pertes de qualité sont estimées en utilisant le système de classification appliqué aux ventes de maïs au NAM Board*. Les retraits individuels de maïs à partir du silo sont estimés, évalués et additionnés pour donner la valuer totale enlevée. La valuer de la perte est obtenue en déduisaut cette quantité de celle qu'on aurait eu si tous les retraits avaient été de qualité supérieure. Les valeurs obtenues pour les silos individuels varient entre 0,15 K et 15,51 K; exprimées en pourcentages de la valeur maximum possible du maïs, ces pertes varient entre 0,7% et 24,2%.

Les pertes indirectes sont évaluées au montant des dépenses des fermiers en insecticides.

*National Agricultural Marketing Board

La valeur totale de pertes subies par les fermiers stockant les épis (c'est à dire pertes quantitatives, qualitatives et indirectes) varie entre 2,16 K et 36,25 K avec une moyenne de 10,00 K et une médiane de 6,55 K. Les pertes totales par fermier et par silo varient entre 2,16 K et 9.06 K (moyenne 5,38 K, médiane 3,56 K). La perte supportée par le fermier à Chalimbana avec un silo est évaluée à 20,05 K. A une exception près, les pertes en qualité subies par les fermiers sont plus grandes que les pertes de poids.

Du point de vue sociologique, les pertes de poids sont estimées en utilisant le prix moyen obtenu pour les exportations de maïs de la Zambie, adjusté, dans la mesure du possible, pour le transport, la manipulation et d'autres coûts rejaillissant sur ce prix. Les pertes en qualité et les pertes indirectes sont évaluées en utilisant une méthode semblable à celle employée pour les fermiers individuels.

La valuer totale de la perte supportée par le pays résultant des dégâts subis par les huit fermiers à Chivuna et à Chalimbana dont les pertes ont été estimées, est évaluée à 95,05 K.

Il faut souligner que toutes ces valuers sont basées sur les résultats d'une seule année de stockage et ne sont valables que pour les fermiers choisis, et non pour le petit fermier en général en Zambie.

Les coûts et les profits pour le petit fermier qui stocke son maïs de la façon recommandée par le Ministère du Développement Rural sont estimés.

Ces recommandations sont:

(a) le stockage doit se faire sous la forme grains,

(b) les silos doivent être recouverts de terre à la fois intérieurement et extérieurement,

(c) l'insecticide (malathion) doit être appliqué au début du stockage.

Etant donné que ces recommandations sont plus une variation des techniques existantes qu'un changement pour des techniques entièrement nouvelles, il est décidé d'utiliser une approche marginale pour leur évaluation et de comparer les suppléments de coût et les suppléments de profit dûs au changement. Les deux coûts principaux, pour un fermier adoptant le système recommandé de stockage sont ses dépenses en insecticide et la valeur du temps qu'il a passé à égrener son maïs, recouvrir son silo et appliquer l'insecticide.

Les informations concernant le temps pris pour recouvrir le silo et appliquer l'insecticide sont obtenues en étudiant la construction des silos de simulation à Mt. Makulu, et en enregistrant le temps passé pour appliquer le malathion dans les silos de grains égrenés; pour l'égrenage, le temps est pris à partin d'une étude allemande faite avec des fermiers de la Province du Sud (Gesellschaft für Regionale Strukturentwicklung, 1971).

Le tarif auquel le temps est estimé est basé sur des informations obtenues à partir des questionnaires sur le travail effectué par les fermiers et sur les règlementations statutaires existantes concernant le travail de ce type. On prend en considération la disponibilité d'emploi, le fait que le fermier puisse faire le travail, sa préférence possible pour les loisirs et le fait que l'égrenage du maïs est souvent effectué, du moins en partie, par l'épouse et les enfants du fermier. La prise en considération de ces facteurs conduit à une gamme de coûts dépendant des hypothèses faites. Si un fermier stocke la quantité d'épis (10 sacs) mise dans les silos de Mt. Makulu, son prix de revient, en considérant les hypothèses les plus vraisemblables, sera de 2,80 K. Dans le cas de grains non traités (7 sacs) dans un silo recouvert de terre, la valeur comparable sera de 0,80 K.

L'adoption du système recommandé de stockage conduira aussi à des coûts qui ne sont pas facilement évalués, tels que le temps passé à apprendre la nouvelle méthode et le risque de faire des erreurs.

Le profit quantitatif qui suit l'adoption de la méthode améliorée de stockage est estimé en utilisant les données obtenues sur les pertes physiques à partir de maïs stocké par différentes méthodes à Mt. Makulu. On considère qu'il est représenté par la quantité supplémentaire de maïs qui sera disponible si, dans tous le cas, le stockage du maïs a été effectué selon la méthode améliorée. Cette quantité est trouvée en appliquant le pourcentage de perte de poids qui se produit dans le maïs stocké de la façon améliorée à la quantité de maïs dans les autres silos, et en déduisant la quantité obtenue, des pertes qui se produisent réellement. Le maïs supplémentaire dont pourra disposer un fermier stockant normalement les épis avec leurs enveloppes, est de 39 kg; il est de 8 kg pour un fermier stockant son maïs en grains. Ces quantités sont estimées à la valeur moyenne à laquelle les achats sont faits par les fermiers choisis, étant donné que, après une mauvaise récolte, les achats sont plus courants que les ventes au cours de la période de stockage. Les valuers obtenues de cette manière sont de 1,73 et 0,36 K.

Le profit qualitatif pour un fermier adoptant la méthode recommandée de stockage est estimé en appliquant le système de classification en qualité du NAM Board à chaque retrait de chacun des silos. Ces retraits sont estimés et une valeur totale est obtenue. Pour effectuer une comparaison entre silos, ces valeurs sont réduites à l'unité commune d'un sac de 90 kg, la qualité du maïs de ce sac étant la moyenne des qualités de chaque retrait de maïs du silo. La valeur supplémentaire d'un sac représentatif de maïs stocké de la manière recommandée est de 0,67 K pour 90 kg si l'on compare au maïs stocké en épis avec enveloppes, et de 0,22K pour 90 kg si on compare au maïs stocké en grains non traités. Ces valeurs sont utilisées pour obtenir les profits qualitatifs; ceux-ci sont de 2,68 K pour un fermier qui stockait sous forme d'épis et de 1,54 K pour un fermier qui stockait sous forme de grains, calculés sur la base des quantités stockées à Mt. Makulu de 10 sacs d'épis (équivalents à 4 sacs de grains) et de 7 sacs de grains.

La conclusion à laquelle on arrive en comparant les coûts et les profits est que, sauf quand les hypothèses les plus défavorables sont faites, les profits sont plus élevés. Le rapport le plus probable est de 1:1, 6 pour un fermier stockant ordinairement les épis avec leurs enveloppes, et de 1:2,4 pour le fermier stockant ordinairement les grains. Cette analyse est basée sur les pertes supportées dans les silos de simulation.

En dehors du profit nutritionnel obtenu par les fermiers utilisant la méthode recommandée, il y a d'autres profits qui ne sont pas compris dans l'évaluation: plus grande sécurité de savoir que son maïs sera en bon état, réduction de l'attaque des maïs par les insectes venant du silo et plus large utilisation de maïs SR 52.

Les côuts et les profits d'une amélioration du stockage sont discutés pour la Zambie toute entière mais, à cause du petit effectif de fermiers choisis et de la possibilité de sa non représentativité, ils ne sont pas quantifiés.

Pour permettre aux pays africains de planifier des programmes de développement pour améliorer le stockage, il est recommandé que l'analyse coût-profit soit appliquée aux données obtenues à partir de régions où la technique améliorée est proposée, étant donné qu'il est peu probable que les résultats qui découlent d'une situation soient transférables à une autre.

Des recommandations sont également faites sur l'éxécution des projets de recherches prévus pour obtenir la base nécessaire de données techniques et économiques indispensables.

RESUMEN

Evaluación de perdidas en maíz almacenado, en una selección de pequeñas explotaciónes en Zambia, con particular referencia al desarrollo de metodolgía.

Los términos de referencia de este proyecto fueron: (1) desarrollar una metodología satisfactoria para evaluar la extensión de las pérdidas; (2) establecer una relación razonable y fiable coste-beneficio para una técnica sencilla y mejorada de almacenamiento en la explotación; y (3) recomendar si debería emprenderse un proyecto a más largo plazo sobre una zona mas extensa para evaluar la relación coste-beneficio de técnicas mejoradas de almacenamiento, dentro de la planificación de programas de desarrollo.

De acuerdo con estos criterios, el artículo proporciona un estudio detallado de diversos métodos de fijación de pérdidas. Estos métodos se aplican al maíz almacenado por pequeños agricultores de ciertas zonas seleccionadas de Zambia, y se hace una evaluación de los costos y beneficios que tendrían dichos agricultores adoptando una técnica mejorada de almacenamiento.

El concepto biológico de pérdida depende de la definición de pérdida. Se discuten las pérdidas de cantidad, calidad y causas de las semillas. El problema se radica en obtener una medida que pueda ser traducida a términos económicos. Se discuten también técnicas de muestreo y de toma de muestras del grano. Se practicaron varios sistemas de utilizar tales muestras para estimar las pérdidas, los cuales pueden dividirse en métodos volumétrico, gravimétrico e indirecto. Se da una descripción de los principios subyacentes en cada uno de ellos.

El concepto de los economistas sobre 'pérdida' reside en estudiar las consecuencias económicas que se derivan de la disminución de la cantidad y la calidad de un producto durante su almacenamiento. La valoración de dichas consecuencias puede hacerse desde el punto de vista de la persona que sufre la pérdida o desde el del país como un todo.

El principio fundamental subyacente en la evaluación es una fijación de la oportunidad, o de la utilización prevista, lo cual es una condición previa a la ocurrencia de la pérdida, y el sacrificio o costo originado como resultado.

Cuando se evaluan pérdidas desde el punto de vista del agricultor, puede aplicarse este principio a sus cuatro principales usos de los productos alimenticios almacenados — alimentación humana, venta, alimentación animal y semilla para la siembra del año siguiente. Cuando las pérdidas se fijan desde el punto de vista social, el valor que se atribuya puede basarse en el precio al cual el país vende (o podría haber vendido) dicho producto.

Las pérdidas medibles pueden ser:

(1) Cuantitativas o cualitativas
El coste originado por la pérdida de calidad puede fijarse utilizando un sistema de clasificación y los diferentes precios correspondientes.

(2) Directas o indirectas
Pérdidas directas son las que resultan directamente de los daños ocurridos en un año determinado. Pérdidas o costos indirectos son los debidos a la anticipación de que las pérdidas van a ocurrir.

(3) Valores — bruto o neto
El producto dañado puede tener una utilización alternativa. En esta salida alternativa, hay que tener en cuenta su valor para fijar la pérdida neta.

Algunas pérdidas que tienen significación económica no se pueden evaluar facilmente. Las pérdidas nutricionales que pueden impedir el trabajo del agricultor, o tener como consecuencia un gasto extra en cuidados médicos, constituyen un ejemplo.

El programa de investigación comenzó con una selección de las zonas. La selección se hizo visitando las zonas accesibles desde la base del proyecto. Se seleccionaron dos zonas; una, la de Chivuna, en la cual generalmente se almacenaba el maíz en mazorca con espatas; la otra, Chalimbana, donde, generalmente, se almacenaba el maíz desgranado. Se da una descripción de las áreas del proyecto, de su clima y de sus almacenes, así como la descripción del sistema de cultivo del maíz.

Se realizó una encuesta entre los agricultores de la áreas seleccionadas. La información recogida incluía datos económicos y sociales básicos relativos a agricultores individuales, e información sobre sus almacenes y prácticas de almacenamiento. Otras secciones del cuestionario abarcaban las pérdidas y la utilización de su maíz almacendo.

Al final del período de almacenamiento, se realizó una segunda encuesta, entre los agricultores seleccionados, para obtener los datos necesarios para la evaluación económica de las pérdidas.

Una tercera encuesta, más corta, se realizó en las áreas adyacentes a las seleccionadas, para conocer si los métodos de almacenamiento de los agricultores elegidos diferían de los de los agricultores vecinos. Se comprobó que no había diferencias notables.

Los resultados de las encuestas mostraron en conjunto que la mayoría de los agricultores habían recibido una educación primaria escasa. En la zona donde se almacenaba el maíz desgranado, Chalimbana, la mitad de los agricultores realizaban además otros trabajos fuera de la explotación. Esto se debía, probablemente, a la proximidad de la capital, Lusaka. En Chivuna, no era fácil encontrar trabajo fuera de la explotación y sólo una minoría de agricultores realizaban trabajos adicionales a los de sus explotaciones.

Los agricultores de Chalimbana procedían de diferentes áreas y habían introducido la idea del almacenamiento del maíz desgranado, mientras que los de Chivuna eran agricultores de la propia localidad.

En ambas áreas, el maíz es la cosecha principal, siguiéndole en importancia el cultivo del cacahuete. El maiz se cultiva sobre todo para proporcionar alimento a la propia familia, vendiendose el sobrante, inmediatamente después de la recolección, casi siempre al gobierno. Esto es lo más corriente de grado mas alto. La variedad de maíz mas cultivada, sembrada por el 70% de los agricultores de Chivuna, es el híbrido SR52. Sin embargo, el 50% de los agricultores de Chivuna cultiva, bien unicamente o bien de modo adicional, un tipo local de maíz derivado de la variedad Hickory King, y el 25% cultiva una variedad locale indefinida. El 75% de los agricultores que cultivan a la vez SR52 y otra variedad venden toda la producción de SR52 a causa de su pobre calidad para el almacenamiento, comprobándose que los agricultores eran conscientes de los problemas que plantea el almacenamiento del maíz híbrido y su major susceptibilidad a los ataques de los insectos. En Chalimbana, se cultiva menos cantidad de SR52 que en Chivuna, pero su cultivo se está incrementando. En ambas áreas, los insectos eran la causa principal de las pérdidas mencionadas por los agricultores. La estimación de las pérdidas hecha por los agricultores era baja, generalmente inferior al 5%, pero existían ciertos prejuicios de interpretación relacionados con esta cuestión. Los agricultores estuvieron más conscientes de sus pérdidas cuando vieron que la importancia de las mismas era motivo de una investigación; esto quizá pudo haber afectado a la estimación dada por ellos. El maíz dañado se utiliza para la alimentación animal o para la elaboración de cerveja.

Más del 75% de los agricultores, que almacenaban el maíz desgranado utilizaban algún insecticida, pero sólamente uno aplicaba el tratamiento recomendado a base de malathion, aplicando los demás DDT o BHC. De los agricultores que almacenaban maíz en mazorca, el 66% utilizaba algún insecticida, principalmente BHC. Los análisis de los residuos sobre el maíz en mazorca mostraron una defectuosa protección del insecticida sobre el grano de maíz una vez quitadas las espatas y desgranadas las mazorcas. En el caso de un agricultor que utilizaba DDT y BHC sobre maíz desgranado se comprobó la existencia de residuos de los insecticidas a través de toda la estación, pero a pesar de ello los insectos continuaban causando daños considerables.

La primera encuesta realizada se utilizó para seleccionar los agricultores para un programa de muestreo. Este se llevó a cabo quincenalmente durante todo el período de almacenamiento. Se sacaba maíz de los almacenes y se analizaba en cada operación de muestreo al objeto de determinar la causa y extensión de las pérdidas. La causa principal era la infestación de insectos, siendo las especies más importantes *Sitotroga cerealella* (Oliv.), *Sitophilus zeamais* Mots. y *Tribolium castaneum* (Herbst.). La infestación por *S. cerealella* se reducía considerablemente con el almacenamiento del maiz desgranado, pero existía un inesperado alto nivel de grano dañado en el fondo de dichos almacenses al final de la estación. Las pérdidas causadas por mohos y roedores eran despreciables. También eran despreciables las pérdidas de semilla por causa de condiciones climáticas, corto período de almacenamiento y selección por los agricultores.

En el proyecto base, se llevó a cabo una simulación de almacenamiento de agricultor en Mt. Makulu, utilizando almacenes similares, en cuanto a su construcción, a los utilizados por los agricultores cuyos almacenes fueron objeto de muestreo. Dichos almacenes se llenaron con maíz de los agricultores de las áreas en estudio. Las mazorcas se almacenaron, tanto con las espatas como sin ellas, así como maíz desgranado, tanto no tratado como tratado con la dosis recomendada de malathión (100 g. de polvo de malathión al 1% por 90 kg de maíz). Se tomaron muestras a intervalos regulares para simular la forma en que los agricultores iban sacando el grano de sus almacenes, tomandose sub-muestras para análisis. También se introducían en dichos almacenes pequeñas muestras comparativas para ayudar a la fijación de las pérdidas.

El contenido de humedad del maíz se elevaba desde aproximadamente un 10% al comienzo del almacenamiento a un máximo del 14—15% durante la estación de las lluvias, descendiendo un poco después al final de dicha estación.

Las termitas atacaron a dos de los almacenes simulados de barro. Esto no sucede generalmente en la práctica, en los almacenes de los agricultores, ya que no están hechos normalmente con madera susceptible a dicho ataque.

Las pérdidas de calidad se estimaron utilizando un sistema de clasificación basado en las normas de aceptación del producto en los mercados locales en conjunción con la apreciación subjetiva de los agricultores. La calidad aceptable para los agricultores iba disminuyendo conforme descendian sus reservas de grano. En los almacenes simulados, se mantuvo una calidad aceptable para el maíz almacenado desgranado. Sin embargo, donde los agricultores almacenaban el maíz en mazorca, y se seleccionaban para ello las mazorcas con espatas bien apretados, dicho maíz conservaba su calidad casi tan bien. El maíz conservado en mazorca sin espatas, era el que sufría una deterioración una deterioración de la calidad más acentuada.

Las pérdidas en cantidad, en los almacenes simulados, se obtenían pesando las extracciones de maíz y deduciendo el total de las mismas del peso del maíz introducido en el almacén. Para su comparación, las pérdidas se estimaban bajo la base de peso seco. Las pérdidas de peso eran de un 1% o menores en los almacenes de maíz desgranado tratado (excepto en los almacenes donde hubo ataque de termitas), del 3% en los almacenes de maiz desgranado sin tratar, y del 13% en los almacenes de maíz en mazorca en que no se habian seleccionado las mazorcas con espatas apretadas. Las mazorcas sin espatas sufrían, en los almacenes, una pérdida del 9%. Sin embargo, en este último caso, había tenido lugar probablemente una pérdida adicional superior al 5%, en el transcurso del tiempo desde la recolección hasta la puesta en los almacenes; en otros casos las pérdidas anteriores al comienzo del almacenamiento eran insignificantes. La estimación de las pérdidas en el almacenamiento de maíz en mazorca se complicaba por las operaciones de conversión a peso de maíz desgranado.

Con objeto de ensayar la validez de las diversas técnicas de fijación de pérdidas, se aplicaron las mismas a las muestras de maíz sacadas de los almacenes simulados, y los resultados se compararon con los obtenidos mediante peso.

Por análisis de las pequeñas muestras pesadas dentro de dichos almacenes, se demostró que el tiempo de almacenamiento era importante para el maíz desgranado, calculándose una pérdida diaria de 0.054%.

El peso de un volumen estandar de grano a través del período de almacenamiento, comparado con el del momento de iniciación de dicho periodo, constituía un método razonablemente seguro y práctico, habiéndose hecho, por variedad de maíz, las adaptaciones precisas en cuanto a cambios de contenido de humedad y mezcla de polvo. Esta estimación se mejoraba incluyendo datos sobre porcentaje de grano dañado y, tiempo de almacenamiento en el análisis de regresión. Sin embargo, la colecta de tales datos consumía mucho tiempo.

El peso de un número estandar de granos (100) de una muestra no resultó muy útil en la estimación de pérdidas. Se encontró una fórmula conveniente de comparación de los granos con daños para niveles intermedios de daños, pero poco segura para bajos niveles. Dicha fórmula podría ser útil para la estimación de pérdidas de una sola muestra. El número de insectos cribados o encontrados, y el porcentaje en peso de polvo obtenido de las muestras eran difíciles de utilizar en la práctica y además no eran buenos indicadores de pérdidas de peso.

El porcentaje del grano dañado se utiliza comunmente para fijar las pérdidas, pero deja de ser seguro a altos niveles de daños. En los almacenes simulados de maíz desgranado, se encontró que el 1% de daño equivalía a 0.12% de pérdida de peso. A causa de la localización del daño en el maíz en mazorca con espatas la relación entre porcentaje de pérdida de peso y daño era diferente, siendo el porcentaje de pérdida de peso igual a 0.22 veces el porcentaje de grano dañado más 0.15% por cada semana de almacén.

Las pérdidas de maíz, en los almacenes de maíz en mazorca de los agricultores, se incrementaban conforme avanzaba la estación, y al final del período de almacenamiento eran del 8—10%. Sin embargo, cuando se tomaba en cuenta la reducción de los existencias a través de la estación, las pérdidas medias se elevaban al 2—5% sobre le conjunto del período de almacenamiento. La baja magnitud de estas pérdidas demuestra el beneficio de la selección de mazorcas que era practicada por los agricultores seleccionados. Los agricultores que almacenaban mayores cantidades de maíz durante mas largos períodos eran los que sufrían los mas altos porcentajes de pérdidas. Debido a la pobre cosecha, sólamente uno de los agricultores seleccionados en Chalimbana pudo almacenar maíz desgranado durante la estación de almacenamiento. Almacenó una variedad híbrida y sufrió una pérdida del 6% aproximadamente.

Se sugiere que los métodos analíticos empleados en la estimación de pérdidas se apliquen primeramente al maíz bajo diferentes condiciones ambientales, climáticas y de almacenamiento, y luego a otros productos almacenados.

En la evaluación de las pérdidas de los agricultores seleccionados se hizo un uso considerable de sus sistemas de consumo de maíz, cuyos datos se recolectaron durante las visitas de la encuesta. A cada agricultor se le preguntaba sobre la cantidad de maíz que había sacado de su almacén desde la visita anterior y sobre la manera en que había utilizado dicho maíz.

Los agricultores eran conscientes de que su maíz sufría daños, decidiéndose que la forma mas realista de hacer la evaluación de sus pérdidas en peso era que dicha pérdida estuviera limitada a las del maíz utilizado por los agricultores para el uso (o usos) más bajo en orden de sus prioridades. Este principio se aplicó a cada agricultor. Los valores obtenidos para los agricultores de Chivuna se alineaban desde K0.36 de un agricultor que tuvo vacío uno de sus almacenes a principios de Febrero, hasta K12.33, de un agricultor con cuatro almacenes cuyo maíz duró a través de toda la estación. Las pérdidas de un agricultor, en Chalimbana, que almacenó grano durante toda la estación se valoró en K1.78. Las pérdidas de peso se fijaban también utilizando el precio medio al cual los agricultores compraban el maíz. Los valores obtenidos fueron similares a los encontrados por métodos más precisos, debido a la pequeña escala en que se llevaron a cabo las transacciones de maiz y a la ausencia de diferencias significativas en los precios del maíz comprado para diferentes propósitos. Las pérdidas de calidad se determinaron utilizando el sistema de clasificación aplicado a las ventas de maíz en la NAMBoard.* Las retiradas individuales de maíz del almacén se valoraban en precio y se sumaban con objeto de obtener valor total del maíz sacado' El valor de las pérdidas se obtenía deduciendo esta cantidad de la que se hubiera obtenido si todas las salidas hubieran sido de la calidad superior. Los valores obtenidos para almacenes individuales variaban entre K0.15 y K15.51; expresados como un porcentaje del máximo valor posible del dicho maíz, las pérdidas alineaban entre 0.7% y 24.2%.

Las pérdidas indirectas se evaluaron en relación con la cantidad que los agricultores gastaban en insecticidas.

El valor total de las pérdidas sufridas por agricultores que almacenaban maíz en mazorca (es decir, cuantitativas, cualitativas e indirectas) variaba entre K2.16 y K36.25, con una media de K10.00 y una mediana de K6.55.

El total de pérdidas por agricultor y por almacén se alineaba entre K2.16 y K9.06 (media K5.38, mediana K3.56). La pédida tenida por un agricultor, en Chalimbana, con un almacén, se valoró en K20.05. Con una excepción, las pérdidas de calidad que sufrieron los agricultores fueron mayores que las debidas a pérdida de peso.

Las pérdidas de peso bajo el punto de vista social se fijaron utilizando el precio medio límite obtenido en las exportaciónes de Zambia de maíz, ajustado tanto como fue posible en cuanto a transporte, manipulación y otros costes reflejados en este valor. Las pérdidas de calidad y las indirectas se evaluaron por medio de un método similar al utilizado por los agricultores individuales.

El valor total de las pérdidas en el país como resultado del daño sufrido por los ocho agricultores de Chivuna y Chalimbana, cuyas pérdidas fueron evaluadas, se elevó a K95.05.

Se debe subrayer que todos estos valores de basaron en los resultados de un solo período de almacenamiento y son sólamente validos para los agricultores seleccionados, y no para el pequeno agricultor de Zambia en su conjunto.

También se fijan los costos y beneficios, para el pequeño agricultor, del almacenamiento de su maíz en la forma recomendada por el Ministerio de Desarrollo Rural.

Estas recomendaciones son:

(a) el almacenamiento debe hacerse con maíz desgranado,

(b) los almacenes deben ser cubiertos con barro tanto por dentro como por fuera,

(c) debe añadirse un insecticida (malathion) en el momento del almacenaje.

Teniendo en cuenta que estas recomendaciones constituyen más una variación de las técnicas existentes que un cambio a unas técnicas enteramente nuevas, se decidió utilizar un sistema adicional para su evaluación y para comparar los costos extra con los beneficios extra del cambio. Los dos costos mayores para un agricultor, al adoptar el sistema recomendado de almacenamiento, son sus gastos en insecticidas y el valor del tiempo utilizado en desgranar su maíz, cubrir con barro su almacén y applicar el insecticida.

Se obtuvo información sobre el tiempo dedicado a cubrir el almacén con barro y aplicar el insecticida, estudiando las construcciones de los almacenes simulados en Mt. Makulu, y midiendo el tiempo utilizado en aplicar malathion en los almacenes de maíz desgranado; el tiempo del desgranado se obtuvo de un estudio alemán (Gelleschaft für Regionale Strukturentwicklung, 1971) de los agricultores en la provincia del sur.

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*National Agricultural Marketing Board of Zambia (Oficina Nacional de Comercialización Agrícola de Zambia)

La tarifa con la que se valoró el tiempo se basó en una información obtenida de los cuestionarios relativos al trabajo llevado a cabo por los agricultores y de las regulaciones estatutarias existentes para ese tipo de trabajo. Se tuvo en consideración la disponibilidad de empleo, si el agricultor podía realizarlo, si prefería dedicar ese tiempo al ocio, y el hecho de que el desgranado del maíz lo realizan a menudo, al menos parcialmente, la esposa y los hijos del agricultor; la atención a tales factores se tradujo en una serie de costos dependientes de la asunción hecha. Suponiendo que un agricultor almacenaba cierta cantidad de maíz en mazorca (10 sacos), puesto en los almacenes de Mt. Makulu, su costo, dentro del supuesto más probable sería de K2.80. En el caso de grano no tratado (7 sacos) en un almacén cubierto con barro, la cifra comparable sería de K0.80.

La adopción del sistema recomendado de almacenamiento podría también incluir costos que no son fáciles de evaluar tales como el tiempo empleado en aprender el nuevo método y el riesgo de equivocarse.

El beneficio cuantitativo de adoptar el método mejorado de almacenamiento se determinó utilizando los datos obtenidos sobre las pérdidas físicas habidas en el maíz almacenado por diferentes métodos en Mt. Makulu. Se decidió representarlo por la cantidad adicional de maíz que podría haberse tenido disponible si, en todos los casos, el almacenamiento se hubiera realizado con el método mejorado. Dicha cantidad se fijó aplicando el porcentaje de pérdida de peso que tuvo lugar en el maíz almacenado por el sistema mejorado a la cantidad de maíz de los otros almacenes, y deduciendo después la misma de las pérdidas que ocurrían realmente. El maíz adicional que podría haberse estado disponible para un agricultor que almacenaba maíz en mazorca con espatas fue de 39 kg y para uno que almacenaba maíz desgranado de 8 kg. Estas cantidades se valoraron, en precio, a la tarifa media a la cual realizaban las compras los agricultores seleccionados ya que, en caso de mala cosecha, las compras eran más comunes que las ventas en el período de almacenamiento. Los valores obtenidos por estos medios fueron de K1.73, y K0.36.

Los beneficios cualitativos para un agricultor que adoptara el método recomendado de almacenamiento se determinaron aplicando el sistema de clasifición de la NAMBoard a las partidas individuales sacadas de cada almacén. Se fijó el precio de las mismas y se obtuvo el valor total. Para la comparación entre almacenes, dicho valor se redujo a una unidad común de un saco de 90 kg, el cual puede considerarse que contiene maíz de varias categorías en proporción a la cantidad de cada categoría existente en el total del maíz sacado del almacén, y con cada proporción valorada a su precio respectivo. El valor adicional de un saco representativo de maíz almacenado por el sistema recomendado fue de K0.67 por 90 kg cuando se comparaba con el maíz almacenado en mazorca con espatas, y de K0.22 por 90 kg cuando se comparaba con maíz en grano sin tratamiento. Esta prima se utilizó para obtener los beneficios cuantitativos de K2.68 para un agricultor que cambiara su sistema de almacenamiento de maíz en mazorca y de K1.54 para uno que cambiara su sistema de maíz desgranado sin tratar, sobre las bases de las cantidades almacenadas en Mt. Makulu de 10 sacos de mazorcas (equivalentes a 4 sacos de grano) y de 7 sacos de grano.

La conclusión deducida de la comparación de costos y beneficios fue que, con excepción del caso de suponer las condiciones mas desfavorables, los beneficios eran siempre superiores. La proporción mas probable era de 1:1.6 para un agricultor que almacenara maíz en mazorca con espatas y de 1:2.4 para un agricultor que almacenara maíz desgranado. Este análisis se basa en las pérdidas habidas en los almacenes simulados.

Aparte del beneficio nutricional obtenido por los agricultores que utilicen el método recomendado, existen otros no incluidos en la valoración, tales como: mayor seguridad de saber que su maíz se conservará en buenas condiciones; reducida infestación de los cultivos por insectos procedentes de los almacenes y mayor utilización del maíz SR52.

Se discuten también los costos y beneficios que una mejora del almacenamiento pueden suponer para Zambia como un todo, pero teniendo en cuenta la pequeña, y posiblemente no representativa, naturaleza de la muestra de agricultores, no se cuantificaron.

Para facilitar a los países africanos la planificación de programas de desarrollo en el campo del almacenamiento mejorado de productos agrarios, se recomienda la aplicación de análisis costos-beneficios a los datos obtenidos en las zonas donde se pretende introducir técnicas mejoradas, ya que los resultados derivados de una situación concreta no son, probablemente, transferibles a otra.

También se dan recomendaciones sobre la forma de llevar a cabo proyectos de investigación para obtener la base técnica necesaria y los datos económicos locales requeridos.

Introduction

The project was conducted by two staff members of the Tropical Products Institute (TPI); J. M. Adams (Tropical Stored Products Centre), Project Leader/Crop Storage Specialist, and G. W. Harman (Marketing and Industrial Economics Department), Economist. The project leader was in Zambia from 10 May 1973 – 31 May 1974 and the Economist from 1 June – 8 September 1973 and 17 April – 15 May 1974.

Finance up to £8,197 was provided by the Overseas Development Administration (now the Ministry of Overseas Development) of the United Kingdom on the recommendation of the Economic and Social Committee for Overseas Research (ESCOR).

OBJECTIVES

The objectives of the project were:

1. to develop a satisfactory methodology to evaluate the extent of losses occurring in maize (and other important foodstuffs if appropriate) stored on peasant farms;
2. to establish a reasonably reliable cost-benefit relationship for a simple, improved farm storage technique, in the one area and one season during which the project would operate; and
3. to recommend whether a longer term project should be undertaken over a wider area to evaluate the cost-benefit relationships of improved storage techniques to enable African countries to plan development programmes in this field.

HISTORY AND BACKGROUND

The project was initiated in conjunction with a similar one on rice storage in India, which was to be carried out under the auspices of the Institute of Development Studies, University of Sussex, (UK) after the submission of a report to the Ministry of Overseas Development concerning economic research into crop storage in the less developed countries (Lipton, 1971). At the same time a survey into the available literature on losses in rural storage in the tropics had been conducted by the Tropical Stored Products Centre. These investigations revealed a lack of detailed information on losses in such countries at the rural level. Also, much of the information available appeared sketchy and, owing to the various methods used in the assessment of losses, not comparable.

Proposals for the two projects were approved by ESCOR after agreement with the Governments of Zambia and India to act as hosts. The pilot project in India began in late 1973 and finished in April 1974. Recommendations have been submitted concerning its future.

This report concerns the pilot project undertaken in Zambia. Prior to commencement a seminar was held in London under the auspices of the Group for Assistance on Storage of Grain in Africa (GASGA) concerning the methodology of evaluating grain storage losses. Recommendations made at the seminar have been borne in mind throughout the project (GASGA 1973).

FORMAT/OUTLINE OF RESEARCH PROGRAMME

This report seeks to approach the problem of loss on an inter-disciplinary basis. Nevertheless, the authors are aware that many readers will be interested, primarily, in either the biological or economic aspects and therefore these have been kept separate wherever possible.

In Part I the definition of loss and the various methods of estimation currently used are described. Little literature exists on its economic evaluation and the principles on which this should be based are discussed.

The research programme commenced with a selection of areas for investigation. The method by which this was done and a description of the areas themselves are given in Part 2, together with information on the various type of stores used by farmers. This section of the report also includes details of the climatic conditions and cropping pattern under which maize is grown in Zambia.

Comprehensive questionnaire surveys were conducted amongst farmers within the selected areas and also, in less detail, amongst farmers in the surrounding localities. The method of conducting surveys and their findings are dealt with in Part 3, and an assessment is made of the usefulness of the questionnaire approach in measuring losses.

The initial surveys were used to select small farmers — those at or near subsistence level — for a programme of sampling which was undertaken fortnightly throughout the storage period. Simulation of farmer storage was carried out at Mt. Makulu, the project's base. Full details of the methods of sampling, results and of how these were used to estimate farmers' losses are given in Part 4. Various techniques of assessment are appraised.

A simple improved method of storage recommended by the Ministry of Rural Development in Zambia was tested at Mt. Makulu by making a comparison of losses occurring in maize stored in this way with that stored by more traditional methods. Details of this exercise are also provided in Part 4, which concludes with a survey of insecticides used by farmers and in the simulation stores.

In Part 5 and Part 6 the results obtained in Part 4 are used to evaluate farmers' losses and to assess the costs and benefits of the recommended method of storage. It was not possible to obtain a cost-benefit ratio for the recommended method in the field since it has so far been adopted by only a few farmers (p 90). Part 6 also includes a discussion of alternative ways of appraising the value of changes in a storage system.

Part 7 contains the conclusions to be drawn from the project and suggests recommendations to be followed in carrying out a similar one.

PART 1

Definition and methodology

THE BIOLOGIST'S APPROACH

Types of loss

Many people have categorised losses in storage (Freeman 1952, Hall 1955, 1970) and found it difficult to make precise definitions. A brief historical review of different forms of loss is given by Howe (1965). Loss may be measured in terms of quantity and/or quality; the higher the standards set by the consumer the greater is the potential loss in value. Compared with field loss, loss in store is finite since it cannot be reduced by compensatory growth of the crop.

Parkin (1956) divides losses into 'the general estimate' or informed guesswork of the expert, and 'the experimental estimate' based on some actual measurements, however crude, which he considers must be used to discover the real importance of losses in storage. Many examples are given of each.

Hall (1970) includes the following categories of loss:

(i) **Weight loss.** This is the most easily quantifiable loss and may result from the activity of insects, rodents or other pests. In a rural situation this may be undetected if sale is by volume. In commerce, weight loss may be masked by malpractices such as adulteration with water, stones or earth. Insects and frass may remain in the sack whose contents may be bought without checking. The true weight loss may be double the apparent loss when inedible insect remains are sieved off, and an increase in moisture content may mask a loss in dry weight.

(ii) **Loss in quality.** This may be related to a grading system such as those embodied in the Zambian National Agricultural Marketing (Acceptance Standards) Regulations. The presence of insects, their excreta and fungi are all quality losses which can have serious economic consequences.

(iii) **Nutritional loss.** Weight loss causes food loss but this may be disproportionate if selective feeding occurs, for example, rodents and certain moth larvae prefer the germ, thus removing a large percentage of the protein and vitamin content. It is often said that weevils in grain increase its protein content. This occurs because their consumption of the starchy endosperm in preference to the germ apparently increases the percentage of protein in the remainder; so a certain weight of weevilled maize will have a greater proportion of protein than the same weight of an undamaged sample. However, if it had not been attacked it would have weighed more. Nutritional values may also be changed because of fungal damage; in extreme cases toxins, such as aflatoxin, may cause a total loss and the product may have to be destroyed.

(iv) **Loss of seed.** Seed is usually more carefully stored because of its greater value. However, loss may still occur, caused by factors such as infestation, excessive respiration and inappropriate control measures.

Methodology

Any loss assessment project should be carefully planned and possess the following attributes:

(a) Clearly defined and fully described objectives — in many studies this has not been apparent.

(b) To enable comparison of losses to be made, assessment should adhere to a pattern and be repeatable.

(c) A high level of representativeness.

(d) A good framework.

The framework which emerges from a study of the literature consists of:

(i) Survey

(ii) Produce sampling method

(iii) Estimation of loss

These processes will now be considered individually. However, it may be noted that, although many studies that have been made follow this pattern, not all have included every part of the framework.

The survey. This enables the investigator to find an area in which to work and to select farmers from whom the samples of produce will be taken. The location of the area may be influenced by many factors — in the case of this study time and accessibility were the constraints in operation. The choice of sample farmers within the area should be made by the use of a recognised statistical procedure if it is intended to use the data for an estimate of loss applicable to the area as a whole. The most useful method is stratified random sampling, the strata depending on the project emphasis. Selection may be undertaken by a grid design, (De Lima, 1973) or in some cases using lists of families or farms. Fuller details of sampling and its limitations are given by Zarkovich (1965, 1966).

Produce sampling method. This refers to the removal of produce from a farmer's store. The method used is often not mentioned in the literature. If the purpose is to estimate the loss in all of the produce in store at a particular time, for example in estimations based on one or two visits during the season, then sampling must be carried out on all the produce in store (Giles 1964, Davies 1959). Southwood (1966) gives details relating the number of samples per store to costs of sampling. On the other hand, if regular sampling is being undertaken over a season then a sample should be taken from produce being consumed between sampling occasions; to remove produce from elsewhere in the store would disturb the natural progress of loss. Schulten (1972) found that there was little stratification of damage within a store of maize and recommended taking 10 cobs. However for cobs without husks, Kockum (1953, 1958) found a difference between the centre and outside layers of the store's content. Therefore an investigation of damage distribution in the store may be necessary.

The size of the sample of produce is limited by practical considerations, especially if it is being removed for analysis, 10 cobs or 1 kg being a reasonable quantity sufficient for most of the methods of assessment that follow. Some workers apparently ignore the fact that the produce is being consumed on a continuous basis. This explains many of the large losses quoted: for example, 70% damage may occur near the end of the season, yet at this time only 5% of the total crop may be left in store. When taking the sample of produce in the present study a note was made of either the total amount left in store or of the consumption since the previous visit to enable integration of loss and consumption with time.

Estimation of loss may be carried out on a weight, nutritional, quality or seed loss basis.

1. *Weight loss*

Weight loss can only be measured accurately by weighing everything in and out of a store. When this cannot be done it is necessary to make an assessment using what is known as a 'related factor'. By this is meant the employment of a factor with which loss is related, such as percentage damage or bulk density. Methods of doing this may be described conveniently under three headings: volumetric, gravimetric and indirect methods.

(a) *Volumetric.* These methods have been used for years as a grading standard known as bushel weight. This is the weight of a standard volume of grain measured by a standard procedure. It has been used in a variety of ways using various volumes to estimate weight losses at the rural level. For example, Schulten (1972) weighed a standard volume of the sample and the same volume of visibly undamaged grain; Rawnsley (1969) took a standard volume but split it into visibly damaged and undamaged portions, weighing and measuring the volume of each.

(b) *Gravimetric.* These methods only involve the weighing and counting of damaged and undamaged grains and may include equations relating weights of visibly damaged and undamaged grains. They have been commonly used in francophone Africa by such workers as De Luca (1969) and Lepigre (1965). The comparison may either be with visibly undamaged grains from the same sample (Moore *et al.*, 1966) or against a standard undamaged sample, and a comparison is made of mean weights of damaged and undamaged grains related to percentage damage. Weight of 100 grains over the storage period has also been used.

(c) *Indirect methods.* These methods often involve the relation of a particular measurement, for example, weight of a number of grains or weight/volume ratio, to a previously determined standard. Factors indirectly related to loss such as dust weight and insect population may be converted to loss (Hayward, 1955) by producing a graph or formula from experimental results to use in sample analysis.

The most common factor used is percentage damage which Parkin recommended should be studied thoroughly, so that the relationship between it and weight loss could be tabulated. McFarlane (pers. comm.) estimates that in wheat damage is x 3 the loss, in sorghum x 4–5, pulses x 3–5 and in maize x 10 (at low infestation levels). For maize Schulten used a factor of x 4.5, and Lepigre and Pointel (1971) a factor of x 3. The popularity of this technique is due to its simplicity and the small size of the final sub-sample necessary for analysis. A discussion of the advantages and disadvantages of these different methods is contained in Part 4.

Weight loss caused by rodents and birds poses a special problem as these pests normally remove whole grains. Losses attributed to them are often those that are unaccounted for by other methods. Some workers have estimated both rodent populations and consumption (Krishnamurthy *et al.*, 1967). Garg *et al.* (1966) estimated losses at threshing caused by birds. There is a danger in extrapolating such results due to the possible errors in estimating populations and consumption in the field.

2. *Nutritional loss*

This may be estimated by sampling at intervals for analysis of nutrients (Eden 1967). Irabagon (1959) fed infested maize to mice to investigate its food value. Davey (1961) tested the palatability of maize meal that had been infested compared with uninfested meal, and related palatability to free fatty acid content. Moore *et al.* (1966) found no difference for dent maize infested by *Sitotroga cerealella* in percentage nutrients when analysed over a period of four months.

3. *Quality loss*

This may be estimated by applying appropriate grading standards throughout the season. Some workers have found that a measurement of the uric acid content of a sample gives an estimate of its contamination by insects even after their removal (Venkat Rao *et al.*, 1960).

4. *Loss of seed*

This may be measured by germination tests. Many insects and mites attack the germ which is the most nutritious part, but weevils which attack cotyledons, may not have much effect until the population is large (Howe, 1952b). Jotwani and Sircar (1964) using pulses found germination to be related to the number of bruchid emergence holes. Howe (1973) discusses the effect of insects and mites in storage on the viability of seed.

There is obviously a need for loss assessment in the implementation of improved storage methods and to evaluate the effects of these methods both commercially and socially. The danger lies in extrapolating data and using it to support preconceived ideas. Consequently, in using any information one must be aware of its limitations and, for example, any experiment designed to examine improved storage methods should include controls (unimproved methods) and be adequately replicated.

THE ECONOMIST'S APPROACH

Introduction

The economist's approach to 'loss' is to study the economic consequences which flow from the diminution in the quantity and quality of a product while it is in store. This will usually involve a monetary evaluation, although it will seldom be possible to arrive at this by the application of a set formula. Normally, loss in the biologist's sense will also result in an economic loss or cost to the person who has suffered it. For example, if maize is stored by a farmer in order to sell at a later date, and some becomes damaged and unsaleable, he will also suffer an economic loss. In some cases, however, damage to a stored crop can result in an economic gain where, as a result of the diminished quantity of the product available, its price rises and the total receipts of the seller are increased.

Some losses found by a biologist may have no significance in an economic evaluation. It has been shown that selective feeding by pests can result in nutritional loss by the removal of protein and vitamins, but the extent to which this results in an economic loss will depend upon the consumer's demand for quality. Continuing the previous example in which maize was being stored for purposes of sale, the farmer would only suffer a loss if protein and vitamin content were taken into account in the fixing of its price. If this were not done there would be no economic loss from the farmer's point of view. The phrase 'from the farmer's point of view' illustrates another important aspect of loss when viewed by an economist since, although the farmer in the example may not suffer from selling defective maize, its buyer certainly will do. Since this buyer may, at least theoretically, be anybody, two aspects or viewpoints of loss emerge – the farmer's or private, and the buyer's or social. Strictly, the social loss is suffered by the rest of the world, but in practical terms the loss is normally analysed on a national basis. The consequences of storage losses for a country will not be the same as for its farmers individually, and the value to be placed on them will be quite different. The value to be placed on the same degree of physical loss may change with time. This necessarily follows from the fact that loss is subjective and an example may be cited from the present study where, as the storage season progressed and farmers' stocks of grain dwindled, they became less particular about the quality they consumed. From the social viewpoint, the value or cost of losing 'x' tonnes of produce will also change in relation to such factors as its price on the world market and the size of the harvest.

Definition

Before proceeding to methodology it is necessary to consider some general principles. It is first essential to define clearly and carefully the terms 'in store' and 'losses'. In this report 'in store' means the period within which the maize is in a farmer's store.

This is not the definition always used and in a study of peasant storage in Nigeria Antonio (1963) gave it as the period between harvest and consumption, including losses suffered on the way to market and those taking place while the product was in the hands of retailers. It is probable that such differences in definition are one of the reasons for the wide range of loss assessments quoted for the same commodity.

The word 'loss' is susceptible to an even wider range of meanings varying with what is being measured and the discipline of the measurer. As such it is a composite term and a full categorisation must include matters both of a biological and an economic nature. To the economist 'loss' refers to changes in values which occur as a result of the physical alterations of a product while it is in store. Since these changes are usually downwards a loss normally involves an economic cost.

Care has to be exercised in regard to how widely this definition of loss is drawn. This statement is best illustrated by examples. For simplicity these will be taken from the farmer's point of view, although analogous treatment could be given to the social viewpoint. When a stored crop has been damaged there will be certain direct consequences affecting intended opportunities for its use which must now be forgone, such as lower consumption, smaller quantities for sale, and, in the case of the small Zambian farmer, less grain for barter. These losses may be termed 'direct' and may be valued gross or net. In an evaluation of net loss the alternative use for a damaged product is taken into account. For example, maize which was not of sufficient quality to sell might be consumed by the farmer himself. The value of the net loss in this instance would be that of the sales foregone less that placed on the maize eaten by the farmer.

Other direct costs which may arise due to damage are those such as re-bagging or sieving a crop which, if damage had not occurred, would either not have been incurred, or if incurred, been lower.

Apart from the direct results of storage losses there are others arising from them. If a farmer's stored crop suffers damage, he will often seek a method of prevention. Whatever method is adopted it will take time and may involve expenditure. Without the incidence of losses these would have been avoided. Again a farmer may want to store a particular crop or a particular variety of a crop, such as hybrid (SR52) maize. However, from experience he knows that if he does this it will be severely damaged, so that instead he stores another. This obviously represents a diminution in satisfaction arising from loss on which a value may be placed.

These costs are an indirect result of damage to a stored crop and are more difficult to assess than those arising directly. Because of this and the fact that the value attributed to them will be less certain, any evaluation should state their amount separately. These indirect costs should not be hidden in an overall gross figure.

Apart from the question of definition, the assumptions underlying a study of losses need to be clearly stated and conclusions drawn only within their limits. This is particularly the case when losses suffered by near subsistence farmers are being assessed. As a number of writers, such as Lipton (1971) and Collinson (1972) have observed that the motivation of maximising profit is not applicable to such farmers. This has two main consequences for the analyst. Where he is making an evaluation not based on actual observed behaviour he should make clear his assumptions about how farmers arrive at their decisions. He should also be careful about drawing conclusions for the country, or indeed for any area of the country, based on the activities of a sector of the economy which may not be typical.

Principles of evaluation from the farmer's viewpoint

The following analysis is generally applicable to losses suffered by farmers in their storing of edible produce. It is applied to the situation of the small farmer in Zambia in Part 5.

The main role of storage in agriculture is to overcome the problem of seasonality, smoothing the supply of a commodity between one harvest and the next. To the extent that losses occur this flow is disrupted. The significance of this disruption depends on a large number of factors, but particularly on the quantity and value of the crop in store at the time when losses are incurred and it is possible to evolve various storage strategies based on information about the timing of damage (De Lima 1973). For example, if the storage period is from September to May and losses are expected from December onwards it will obviously be worthwhile selling any surplus before that period.

The valuation of losses in stored foodstuffs may be based on their intended use. They are stored for four main purposes — sale, feeding to animals, food and seed for sowing the next year's crop. In the case of commercial farmers the first two of these uses are the more important, while the subsistence or near subsistence farmer stores his crop mainly to feed himself and his family. The fundamental principle of evaluation is to analyse what opportunity or intended usage is foregone by the loss occurring and the sacrifice or cost which is borne by the farmer as a result. As shown earlier these costs can be either direct or indirect. Indirect costs are the consequences of the farmer taking action based on experience and hence strictly related to losses suffered in the past. Direct costs are the result of damage to the current crop.

1. *Weight loss*

The subsistence farmer who suffers damage in his store, may become short of food before the next harvest and be forced to purchase food. He may have sufficient money in hand to enable him to do this. If not, he will either have to borrow or to sell something, such as a cow. The cost to him of his loss will be reflected in the amount he has to pay for the food he buys plus, if applicable, any interest he has to pay on a loan. Where a farmer has been forced to sell he may incur an additional cost equivalent to the amount he would have received if this transaction had been undertaken in the normal way less his actual proceeds. In some cases a subsistence farmer whose stored crop is finished may receive help in the form of gifts of food from relatives. In this instance his own costs are negligible, but complete evaluation would have to include the consequences for those making the gift.

When a farmer has to buy produce its cost will depend to a considerable extent on whether there is an established marketing system in which its price is fixed at one level throughout the year. In many countries this does not exist so that prices tend to be high just before the next harvest which is the period at which a farmer is likely to be purchasing.

Irrespective of when damage occurs to a crop stored for food its impact is likely to be felt at the end of the storage period. This is because the immediate result of, for example, damage to a subsistence farmer's maize is for the contents of his store to be used more quickly, since a higher proportion of each withdrawal will be thrown away, or fed to animals instead of being consumed by the farmer himself. Because of this it can be dangerous to attempt an evaluation until the end of the storage period for, although damage and probable loss have occurred it is as yet 'unrealised' and its magnitude can only be assessed very approximately by making assumptions about what will happen later. Other factors influencing the impact of losses are the importance of the stored crop in the farmer's diet, the difficulty and cost of his obtaining credit to buy food, the size of his harvest and his storage habits such as whether he stores just enough to meet his needs and whether he tries to carry over any of his stored food from one year to the next. Where no provision is made in this way a farmer is obviously at the mercy of a possible poor harvest when the amount which he puts in store will be low and therefore the effect of losses proportionately greater.

2. *Quality loss*

Apart from suffering a quantitative loss it is possible that a farmer may also be eating a product which, having been damaged in store, is of poor quality. Where it is possible to buy (or sell) this by grade an evaluation may be based on price differentials. Such a method only provides a rough estimate since these differentials may reflect other factors as well as quality, for example, the competitiveness of other products, custom and governmental decision on what is the 'right' price for each grade.

The quality needed in produce to be used as an animal feedstuff is normally lower than that for human consumption, sale or seed. Despite this, beyond a certain degree of damage, it will become unusable even for this purpose. The effect of the loss will depend very much upon the farmer in question, but its valuation will be based on the need and cost of its replacement. At one extreme this may mean merely putting out animals to graze on common land; at the other of buying expensive substitute feeds to keep valuable animals alive through the cold or dry season.

3. *Nutritional loss*

One important aspect of quality, is that of nutrition. Bad nutrition can mean that a farmer will not have the capacity for prolonged physical effort and this can represent a very definite loss. Unfortunately, evaluation is difficult since most farmers are unlikely to have enough knowledge of nutritional matters even to provide a subjective assessment of any deficiencies they experience. This cannot be overcome by looking at the market for, as observed earlier, nutritional values are seldom of importance in fixing prices. Nevertheless, where nutritional losses have been incurred an attempt should be made to evaluate them. A possible method is to stipulate a standard for, say, maize in a farmer's store based on its protein and vitamin content when it is first stored or, if this is not possible, when the first sample is taken. If this is allotted a price, subsequent diminution in nutritional values can be assessed at the extent to whcih the standard is met. An evaluation of this nature must be fairly subjective, so that its results should be presented separately from those of other aspects of loss.

4. *Loss of seed*

Valuation of the damage to produce stored for use as seed may be based on the cost of replacing that which is affected. This, of course, takes into account only that seed which is known to be faulty before it is sown. There may also be hidden faults resulting in a subsequently lower rate of germination. In these circumstances, where some seed has been retained, an evaluation may be based on its germination rate under laboratory conditions compared with a 'representative' seed. However, if no seed has been kept, although an assessment could be made, it is unlikely that the influence of storage factors could be satisfactorily distinguished from that of all the other factors affecting germination, and therefore would not be of practical significance.

5. *Price and other commercial loss*

When a crop is being stored for future sale and, due to actual or expected damage, the seller is forced to sell at a different time and has to accept a lower price, he will incur a loss equivalent to:

$$L = Q\,(Pe - Pa)$$

L = loss

Q = quantity sold

Pa = price actually received

Pe = price expected to receive

This loss is additional to any quality loss of the crop which may have necessitated the sale. Its assessment may involve making a number of assumptions. These should be stated and, where appropriate, a range of assessments given.

Another cost which a farmer may have to bear in relation to his sales is that of any litigation arising through the selling of faulty produce. This is more likely to happen to a farmer in a developed country. A farmer may also face a loss of goodwill where his goods are regularly of a lower standard than those of his competitors and this will eventually result in his receiving a lower price and/or having difficulty in selling it.

Principles of evaluation from the social viewpoint

If farmer's storage losses are other than negligible there will be costs to be borne by the country as a whole.

The principle governing evaluation is the same as that for the individual farmer — an analysis of the consequences of the loss and the sacrifice it involves. Normally, the repercussions of losses will be greatest where commercial farmers are affected, since their actions can affect the quantity and price of food to a greater extent than those of subsistence farmers who are storing mainly to meet their own needs.

The value to be attributed to losses from the social viewpoint may be based on the prices at which the country concerned traded (or could have traded) the particular produce. The use of its exchange rate in the international market is preferable to one based on internal prices since it minimises the effect of any artificial controls exercised on the domestic market. The exchange rate itself should be the terms at which the particular country traded or could have traded in the year in question. Following this principle, the valuation of social losses will depend on whether domestic production of the commodity concerned is sufficient to meet internal demand. Where it is sufficient there is, at least in theory, a surplus available for export; where it is not then, in the same way as an individual farmer may need to buy food from others 'outside' his farm, the deficiency will have to be met by imports. The reason for making this distinction is that where storage losses occur for 'an export type' good they reduce potential exports and their cost is the amount of foreign exchange earnings sacrificed. In the case of an import type good losses mean that imports will be higher than otherwise and foreign exchange will again be sacrificed.

This analysis will apply irrespective of the intended use of the damaged crop since, whether it was intended for food, seed or animals, the practical effect of its loss will be the same. It will also apply to produce stored by subsistence farmers for, to the extent that they need to buy food etc to make up for their losses, this is not available to meet the demands of other consumers.

The practical application of evaluating social costs by what may be called the Little and Merlees method (1968) may be difficult and a few of the problems it involves will now be examined. One of these arises when a commodity is traded in various grades and may therefore be imported into and exported from a country in the same year. In these circumstances a more exact specification of the damaged produce needs to be obtained before it can be classified as either the imported or exported type. Another problem related to grading is where losses are qualitative. In this case the amount of foreign exchange sacrificed will not be the total value of the exports sacrificed, but the premium that would have been received if these had been of higher quality (with imports the cost is the amount that has to be paid to obtain those of a better grade).

Another difficulty is deciding the basis on which the value of potential exports (or imports) shall be determined. Ideally, exports should be valued free on board (fob) and imports at cost plus insurance and freight (cif), but in cases where these data are not available average unit values may have to be used instead. In the case of industrial projects, border prices are adjusted to take account of transport and other distribution costs involved in taking items to or from the area of the plant's operation. In the case of exports costs are deducted from the amount these would have fetched, and in the case of imports added to the amount paid. For example, if due to losses in store exports are calculated to be £100 lower, then this amount would be offset by, for example, transport costs of £20, leaving a net cost of £80. To what extent this should be done will depend on the importance of these other costs (per unit) relative to the value of the product. It will also depend very much on the data available and whether there are easily defined routes of trade. Zambia trades with countries outside Africa through Tanzania, Mozambique, Zaire or Angola so that evaluation would be unusually complicated.

Ideally the price of all factors used in exporting or importing or importing produce should reflect their true economic cost. The way in which this is done by Little and Merlees is to assign to them accounting prices reflecting their foreign exchange value. This involves a breakdown of costs into their constituent parts such as traded goods, non-traded goods, wages, salaries, profits, taxes (or subsidies)* and foreign exchange content. All these, apart from taxes and foreign exchange content, are then revalued to reflect the real cost of using them and the original item is then 'reassembled' at its new value.

No firm rule can be given as to when such extensive treatment is needed. This must depend on the importance of the project, the amount of data available (such as detailed input-output tables) and whether the conditions prevalent in the economy approximate sufficiently to the assumptions inherent in such analysis (Little and Merlees p 87).

It has been shown earlier that individual farmers suffer indirect costs from their losses and the same is true of the country as a whole. These costs are measures taken in anticipation of losses rather than from those occurring in a particular season. Examples of such indirect costs are those of inspecting and grading produce and those of extension staff advising farmers on improving storage. A major problem in evaluation is that these costs can seldom be attributed solely to the existence of storage losses; for example, in the case of extension staff, advising on storage is only one aspect of their work. Some form of attribution will therefore be necessary. In practice, this may be very difficult.

Social costs may also arise from nutritional deficiencies suffered by farmers and others eating damaged produce. If sufficient details are available valuation may be based on a standard, but this is not very satisifactory. In particular, it cannot take account of such consequences as the lower motivation of affected farmers and the need for greater medical expenditure by the government. There is also the more fundamental problem that damage to stored produce is only one of a number of causes of nutritional deficiency and that its importance compared with other factors such as lack of knowledge about nutrition may be impossible to determine.

Summarising, storage losses involve various costs both to the individual farmer and to the community as a whole. Some of these can be assessed more exactly than others. The approach to their evaluation must be through an analysis of the consequences of losses and opportunities foregone.

* Taxes are deducted from costs, subsidies added.

Part 2

The project areas and their selection

ZAMBIA

General and climatic features

Zambia, (Map 1), has an area of 751,929 km^2 with a population of 4,100,000 (1971) giving a very low population density in many parts of the country, especially around the west, far north, and eastern borders, where most of the subsistence farmers are found. Although situated between 9–18° south of the Equator, the tropical climate is tempered by an altitude of 1,000 to 1,500 m and the general topography is in the form of a series of plateaux. There is a single rainy season which normally extends from November to April, although in some years a little falls in October and May. The heaviest rainfall is from December to February, after which the sunny periods usually become longer until the rain ceases in April. However, in 1974 it carried on well into May and there was less sunshine than normal. The average rainfall for some of the meteorological stations shown in Map 1 is Lusaka (806 mm), Mwinilunga (1,377), Mongu (1,001), Livingstone (727), Lundazi (877) and Kawambwa (1,286). The rainfall is extremely variable and localised, for example, Mt. Makulu had 135 mm in 1¼ hours in a single shower in January 1974.

The temperature during the rainy season is normally 20–22°C, with relative humidities around 80%. After the rains the temperature drops as the cool, dry season advances until June–July, when there may be frost at night in the lower lying southern parts of the country. The day temperature is around 15°C. August becomes warmer and during September and October there is a short, hot, dry season with temperatures of 25–30°C and relative humidities of around 40%.

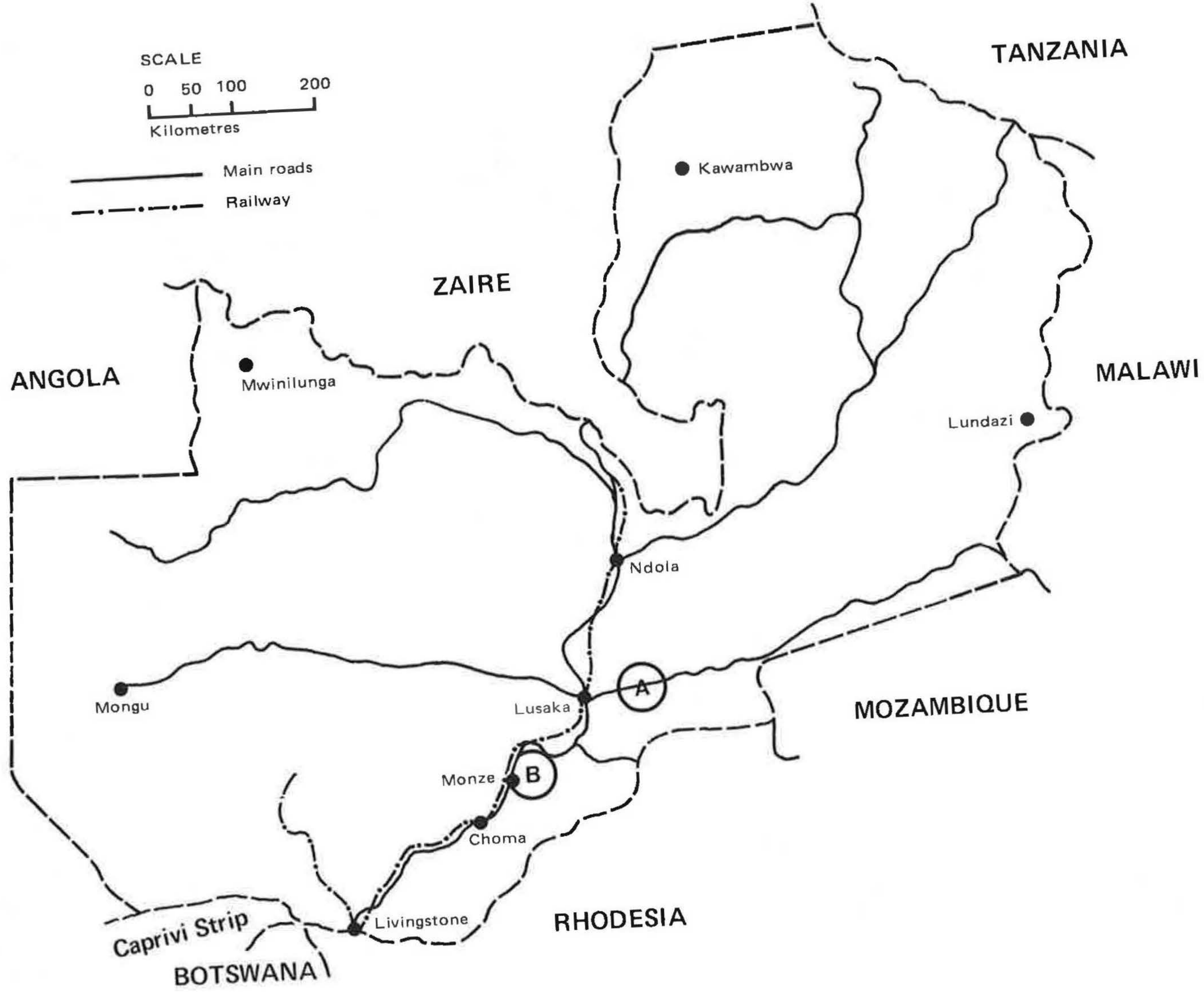
Maize growing

Maize is the most common staple food in Zambia, although in some of the northern areas sorghum is grown. The single maize crop is usually planted, often with a basal fertilizer dressing, in late November after about 50 mm of rain has fallen. Cobs are formed in January and February and normally begin to mature in late February as the hours of sunshine increase (Das 1973). They are harvested from late April onwards, sometimes being left to dry in the field, but more often being placed on special drying platforms (Figure 1). The dry maize for consumption is then put into store and should last until the following harvest.

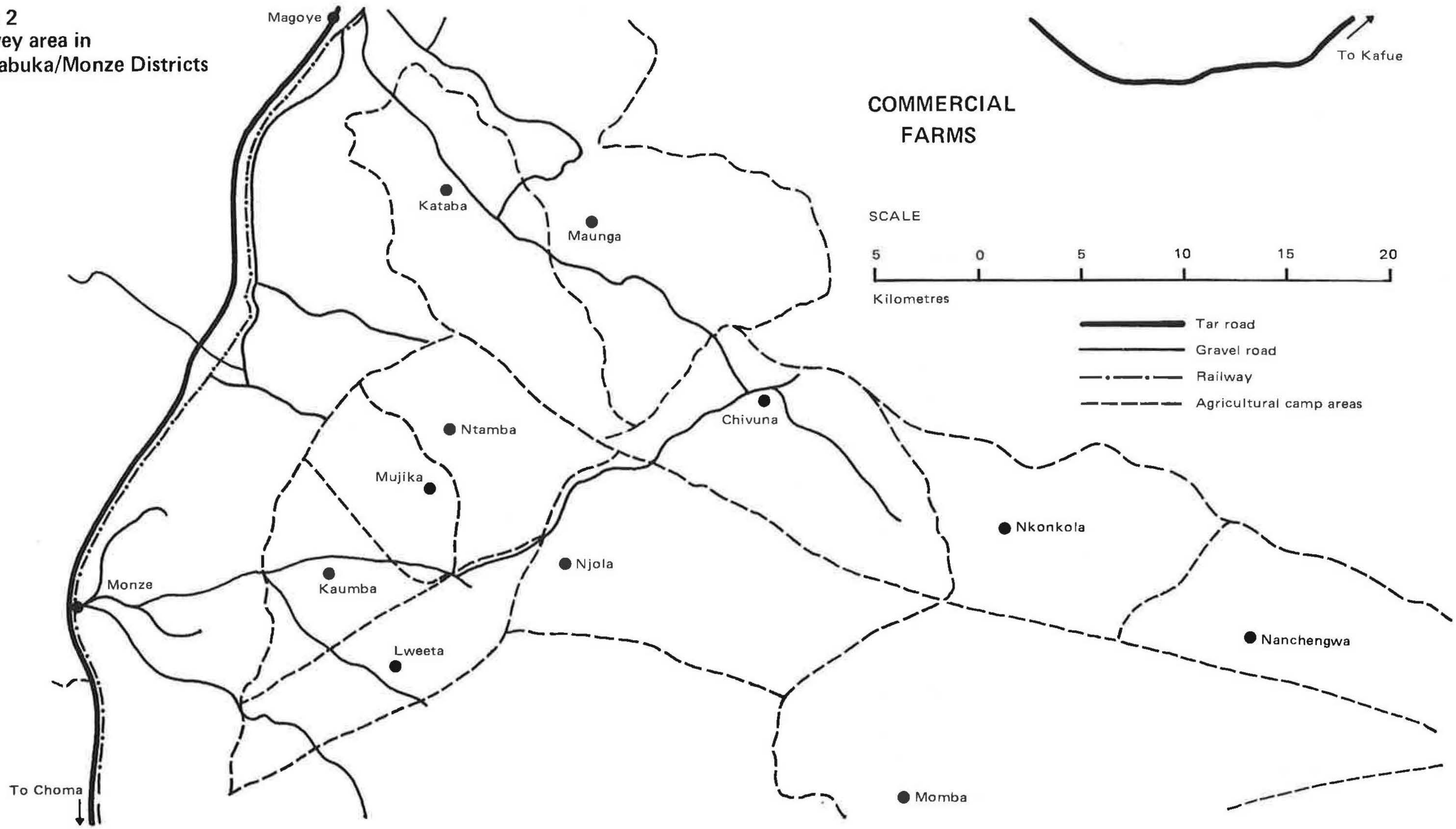
SURVEY PROCEDURE

Because of the need for various essential services, the project was based at the Department of Agriculture Central Research Station at Mt Makulu, approximately 19 kms south of Lusaka. The intention was to draw grain samples every fortnight and, as too much time and money could not be expended on travelling, a suitable area needed to be found within a 150 km radius of the base. Details of possible areas were obtained from the Food Conservation and Storage Unit (FCSU) and the

Map 1
Zambia General



Map 2
Survey area in
Mazabuka/Monze Districts



Extension Branch of the Department of Agriculture. The initial visit to these had been planned for May, but due to lack of transport took place in July. The team was looking for an area with good access in the rains farmed mainly by farmers with little immigrant influence or commercialisation, in which farmers and extension staff were willing to participate in the project. Ideally, an area was required where people stored cobs with and without husks, as well as shelled grain, grew both local and hybrid types of maize and where the climate was not too dissimilar from that of the simulation site at Mt Makulu. Ultimately, two areas were selected on a compromise basis because the method of grain storage was found to be a localised tradition.

Within these areas farmers were selected primarily on the basis of knowledge obtained from the first questionnaire survey (Part 3). No statistically based sampling procedure was adopted because of the pilot nature of the project and the fact that there was no intention of regarding its findings as typical of a specific area. During the survey period, the method of approaching farmers and their reaction to the sampling of their stores was tested, enabling any elements which were unacceptable to them (or to the investigators) to be removed.

CHIVUNA

The first area marked 'A' on Map 1 consists of the southern part of Mazabuka district and the northern part of Monze district in the Southern Province. It is shown in greater detail in Map 2. The sampling was done within the Chivuna agricultural camp area. This camp houses an agricultural assistant, but has no special training facilities. However, nearby at Magoye there is a regional agricultural research station and at Monze an agricultural college. The presence of these has resulted in a number of surveys in the area, especially those concerning farm management.

North of the project area is a block of state land on which there are large commercial maize farms and ranches. To the west over the railway line are the Kafue flats which are used for grazing cattle. Moving east into the project area, the land is at first flat, but becomes more undulating until it reaches the escarpment of the Kafue-Zambezi divide. This area is extremely hilly and is dissected by streams. There are no good roads and the excessive rainfall in 1974 caused it to become at times virtually inaccessible. In the eastern part, the farms tend to become smaller and are very sparse due to the lack of both suitable arable land and communications.

The people of the area are of the Tonga tribe and the plateau Tonga linguistic group who have virtually abandoned shifting agriculture and become settled. Morgan Rees (1958) describes their agricultural improvements.

The nearest meteorological station is at Choma, Appendix A gives a summary of the climatic conditions.

Stores in the Chivuna area are traditionally of the cob type, all having conical grass roofs. There are two traditional stores, both consisting of a cylindrical 'basket' on a raised platform which is usually made of branches supported by strong Y posts. The 'basket' itself may be made of more branches placed vertically like bars (Figure 2), or it may be a 'woven' cylinder of intertwined twigs which is tied on to the platform (Figure 3). This is sometimes made by specialists in the area and bought by the farmer who may roll it home. Both types of store usually have an aperture cut in the top of the wall for access to the cobs, enabling it to be emptied with the roof in place. Regular maintenance consists of re-roofing, cleaning out, and replacement of any broken or termite infested poles, although termite resistant wood is normally used.

The other type of store which is becoming more popular as the farmers become settled is the longer lasting Kimberley brick cob store (Figure 4). This has a mud brick base, covered by a thin layer of cement. On top of this a cylindrical store is built with ventilation gaps between bricks. It usually has a conical grass roof with an

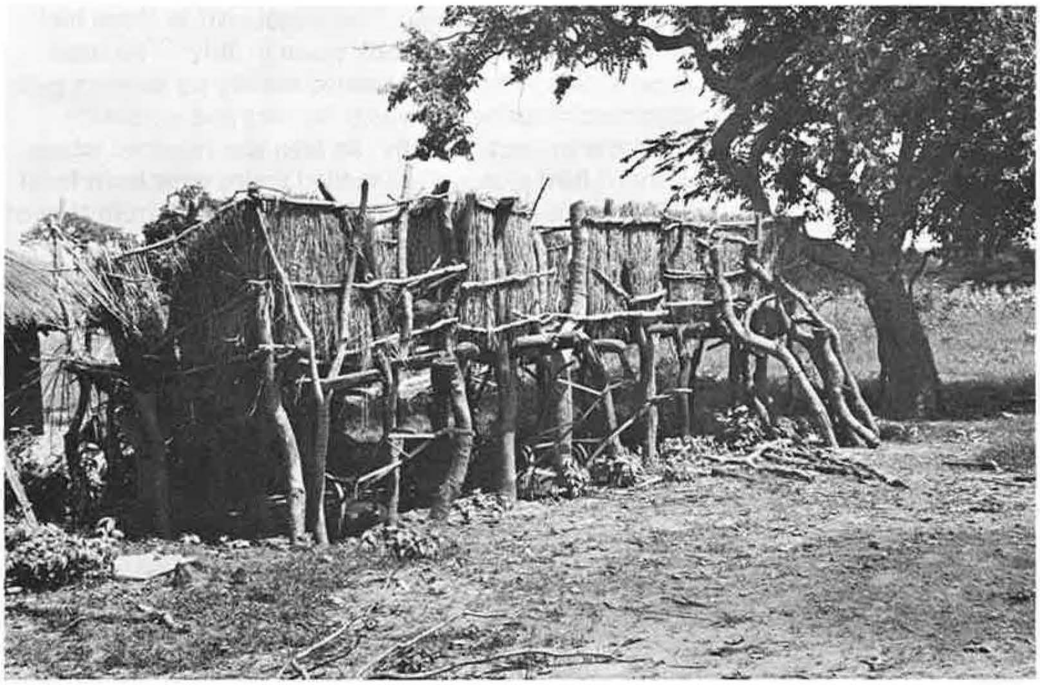


Figure 1 Drying platform

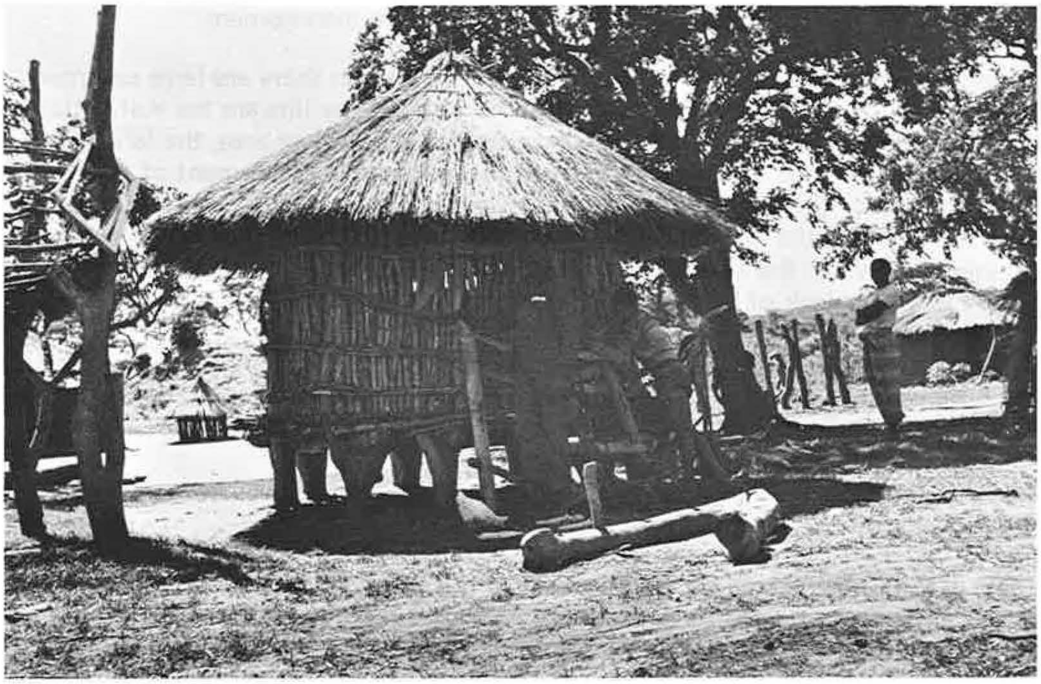


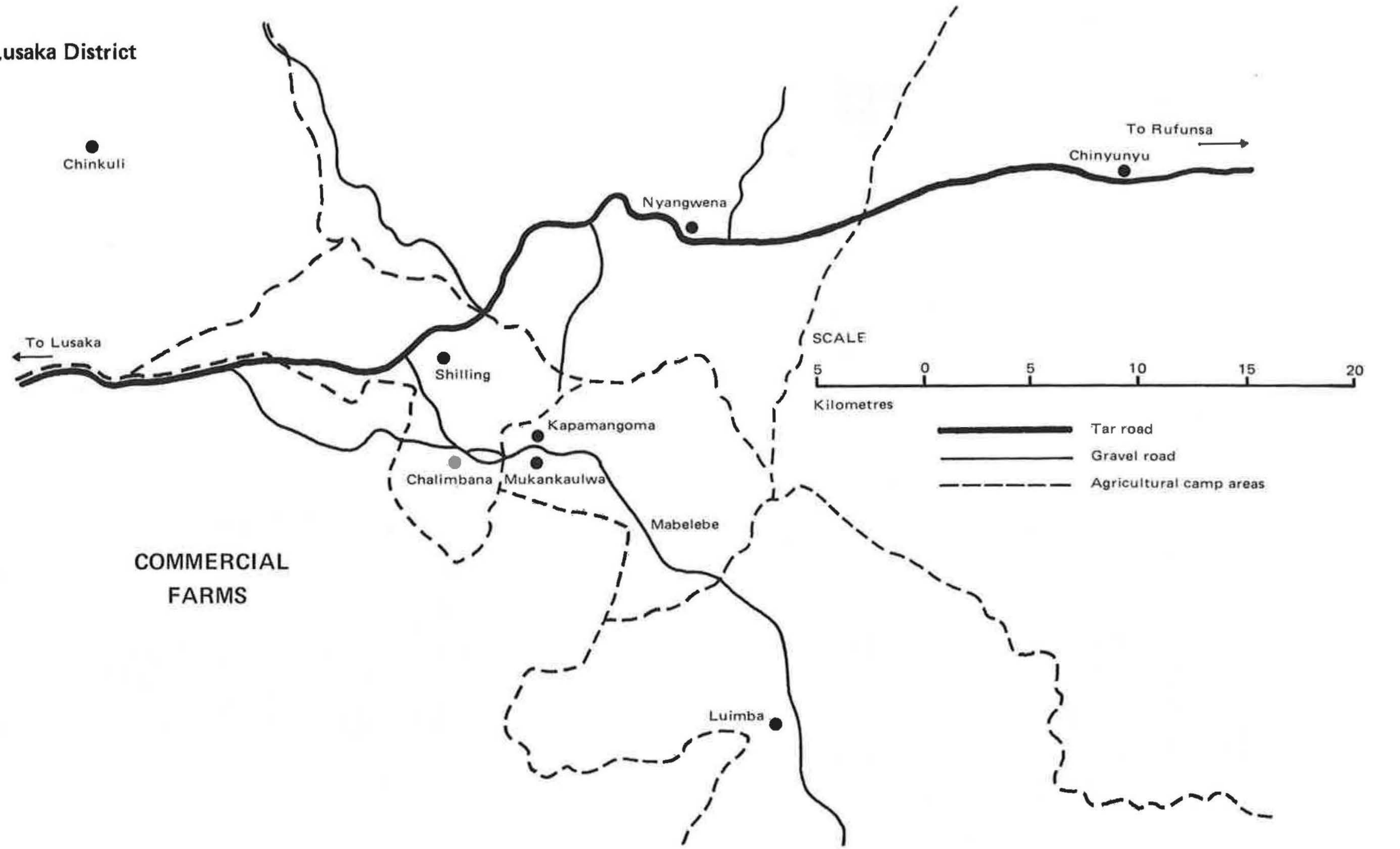
Figure 2 Timber pole type of cob store

access hole just below it. Providing the foundation does not subside and crack, its life is considerably longer than that of the traditional timber stores. The Kimberley brick store is easier to clean out between seasons but, when the water table is high, it may be prone to rising damp in the base if a moisture barrier is absent. This type of store was first introduced several years ago by the Department of Agriculture in the district and is liked by the farmers for its ease of maintenance and permanence.

Figure 3 Woven basket type of cob store

Figure 4 Kimberley brick type of cob store with cement base

Map 3
Survey area in the Lusaka District



During discussions, farmers demonstrated an acute awareness of the problems of cob storage and of the tendency for hybrid maize to have a greater pre-storage infestation than local-type maize and to store badly. Many, after trying hybrids for all their crop, had reverted to growing a local type, often based on the Hickory King (HK) variety, for their domestic usage but continued to grow a hybrid for sale. Choice of cobs for storage was also important, those with husks covering the tips and with no signs of infestation were chosen and carefully stacked in the store. Others, with limited observable damage, were often stacked separately on the drying platform for use between harvest and the time cobs were taken from store. Large cobs with exposed tips and showing more severe infestation were normally sold as soon as possible. The relationship between husk cover and pre-harvest infestation has been documented by Giles and Ashman (1971) in Kenya.

CHALIMBANA

The second area 'B' on Map 1 and Map 3 is based on Chalimbana Agricultural Centre in Lusaka rural district. This was the most accessible area where shelled grain was kept in muddied stores. The nearness to Lusaka has some influence on the farmers and during the project several farmers obtained paid work to offset the poor harvest of 1973. However, the only other possible area within range storing shelled grain was further away and strongly influenced by the presence of Rhodesian immigrants.

Chalimbana is approximately 45 km east of Lusaka, just off the Great East Road to Malawi. The project area extended on both sides of this road to the edge of the commercial farms in the south and to the foot of the Chainama Hills in the north. Most of the area is dissected by numerous streams and gullies, making it difficult for farmers to improve much above the subsistence level. The sample of farmers was taken from two villages, Kapamangoma and Mukankaulwa, which are located in the area covered by the Mabelebe agricultural camp.

Very little survey work had been undertaken previously in this area and, apart from a survey carried out by FCSU, there was no background information. It is a base for a Technical Officer in the extension service and a farmer training centre is also located there.

The nearest meteorological station is at Lusaka International Airport, about 30 km west of Chalimbana. Details of climatic conditions in the Chalimbana area are given in Appendix A.

The main tribe is the Soli and its members belong to the same linguistic group (Tonga) as in Chivuna. This group has been resident in Zambia since the 15—16th centuries and, having entered from the Lake Malawi area via the Zambezi, is distributed from Livingstone to Kabwe (Muchangwe 1962).

The maize grown by farmers in this area is stored after shelling, often being put into store a month or two after harvest and usually not being used for another two months. During this period food may be taken from cobs that have not been shelled.

The store is a platform of branches raised off the ground supporting a cylinder either of branches or plant stalks, such as sorghum. The platform and cylinder are coated with mud, usually on both the inside and outside (Figure 5), but sometimes on the inside only (Figure 6). A single layer is put on which cracks on drying. This is followed by one or two coats to fill in the cracks and to make a smooth finish. A conical grass roof gives protection to the open top and walls. The access hole may be near the roof and permanently open, or it may be small, near the base, and closed by a stone and mud which, on removal, allows grain to pour out into a container. Annual maintenance includes replastering the store, cleaning out and removing the residues harbouring infestation and possibly re-roofing, which may also reduce the carry-over of infestation. It is unusual to find farmers loading new maize on to the remains of the previous year's crop and therefore this form of carry-over is also avoided. Further information on the two project areas is given in Part 3.

Figure 5 Shelled grain store — muddied internally and externally

Figure 6 Shelled grain store — muddied internally only

Part 3

Surveys of storage patterns by small farmers

INTRODUCTION

Questionnaire surveys were conducted in both project areas. They were of two main types. Detailed surveys (intensive surveys) were carried out in those villages from which the farmers chosen for sampling were drawn. Shorter surveys (extensive surveys) were completed in the areas surrounding these villages. In addition, on each occasion when a sample was taken from a farmer's store he was asked about the usage of his maize since the last visit. This information is utilised in Parts 4 and 5.

The main purpose of the intensive surveys was to obtain information on storage patterns. They were also undertaken to provide the background data needed for the evaluation of losses. Two surveys were conducted, one covered the 1972–73 storage season, the other 1973–74. The 1972–73 based survey was in the nature of a trial-run and following this, that based on 1973–74 excluded questions which had been found difficult for farmers to answer. Other questions relating to data already obtained were also omitted, permitting additional points to be raised. Copies of the survey forms used are provided in Appendix B. The general intention behind the order of questions was to provide a logical chain following maize from the time when it was sown to the time when it was consumed, sold or otherwise utilised.

The purpose of the extensive surveys was mainly to enable an assessment to be made of the extent to which the farmers and villages chosen for the project were representative of those over a wider area. A subsidiary purpose was to discover the value of the questionnaire survey approach in assessing losses. A copy of the extensive survey form is given in Appendix B. The questions contained were taken from those in the more detailed survey, but in some cases questions were amalgamated. The extensive surveys were conducted only for the 1973–74 storage season.

All surveys were conducted by personal interview with extension officials acting as interpreters. Once the two project areas had been chosen, these officials were briefed on the kind of farmer required for the survey. The authors were then guided to farmers within the village or area concerned. In some cases officers were over zealous in providing better than average farmers. Consequently, despite efforts at dissuasion it is likely that, in some cases, the sample obtained was biased in this direction. The method used to select farmers for the extensive survey was similar to that for the intensive. The extensive survey was based on agricultural camp areas, which are normally the areas of operation of individual agricultural assistants. Extension officers from the camp concerned were asked to select ten farmers scattered over the area.

Once the farmers had been found the questions were put to them by the extension officer who then translated the answers. This method of investigation obviously places considerable reliance on the person putting the questions. In many cases, such as in Chivuna these interviewers were good, but in others their command and understanding of English was not as high as was desirable. There was also a tendency for them to provide either the answer they thought was expected or to give standardised answers to particular questions, omitting qualifications which the farmer may have given.

Many farmers were interviewed on their farms and in isolation from others. In other cases constraints of time necessitated a number being brought together at one place such as a training centre or chiefs hut. In these instances a certain bias may have arisen from their hearing what other farmers said and knowing that others would overhear them. However, such bias, if it did occur is not thought to have been of much magnitude.

The response rate to individual questions was high with over 90% being answered with little difficulty. Greater problems were experienced with hypothetical questions of the nature 'How did you decide what quantity of maize to grow?' This type of question was omitted from the second survey. There were also instances of farmers attaching a different meaning to a phrase from that which is understood colloquially. For example, in response to the question, 'How much (maize) did you sell?' the answer might be k 4.00, reflecting either price or value, but not quantity. In the 1973–74 survey such a question was rephrased as 'What quantity (of maize) did you sell?' Other subtle differences of interpretation were detected, but some, not apparent from the answers received, may have passed through unnoticed.

Usually, farmers were perfectly willing to be interviewed. Occasionally, however, they were suspicious that the survey was a means of Government checking how well they were farming or of assessing their wealth for taxation purposes. There was also sometimes a tendency for them to become a little restive when the time taken to conduct the survey went appreciably beyond 30 minutes. (The average time taken for the intensive survey was about 40 minutes.)

A further factor bearing on the accuracy of the data obtained is memory bias in favour of events in the more recent past. The two intensive surveys were conducted in August/September 1973 and April/May 1974 whilst the extensive survey was conducted over a period of 3 months between March and May 1974. The relationship of these periods to the dates of the events under question is as follows:

	Intensive Survey I	*Intensive Survey II and Extensive Survey*
Period conducted	Aug.–Sept. 1973	April–May 1974 (Int.) and March–May 1974 (Ext.)
Crop planted	Nov. 1971–Jan. 1972	Nov. 1972–Jan. 1973
Crop harvested	May–June 1972	May–June 1973
Crop stored	Sept. 1972–April 1973	Sept. 1973–April 1974

The dates given are only approximations, but nevertheless show that, other things being equal, some replies are likely to have been more accurate than others, and also that the accuracy of the 1974 intensive survey* is probably greater than the 1973 one. This is particularly the case since confusion may have arisen during the first survey about the period under question. The survey was conducted at the beginning of the 1973–74 storage season and, despite interviewers being requested to clarify the position at the onset of questioning, some answers in the Crops and Storage Section may have referred to events in 1972–73 rather than in 1971–72.

The information obtained from the intensive and extensive surveys has been combined. However, where signficant differences were found to exist between farmers in the project area in which the intensive surveys were conducted, and those in the surrounding districts this is noted. The results of the surveys are given in detail in order to provide full information on the types of farmers surveyed particularly in

*For purposes of convenience the first survey based on the 1972–73 storage season and conducted in 1973 will be referred to in future as the 1973 survey and the second survey based on the 1973–74 storage season and conducted in 1974 as the 1974 survey.

regard to their storage patterns, and also to give data on conditions prevailing during the period in which the project was conducted. However, they are not intended to include all the information obtained.

Where the source of statistics quoted in the text are not shown they have been derived from the replies received during the surveys conducted in 1974, the only exception being information obtained from questions put to farmers in the project area only in 1973.

SURVEYS IN CHIVUNA

Procedure

In September 1973 the intensive questionnaire was conducted with 20 farmers in the Chivuna project area. It had been hoped to take the farmers all from the same village, but this proved impossible since within the time available a sufficient number could not be found at home. Accordingly, the sample was drawn from a number of villages within a radius of about 7 km from Chivuna Agricultural Training Centre. The two main villages from which farmers were taken were Moonga and Cheelo Namayonga. Most farmers were interviewed on their farms. The extension officer acting as an interpreter was competent, having a good command of English. In June 1974 an attempt was made to reach the same 20 farmers who, in this instance, were asked to attend the Agricultural Training Centre on appointed days. Fifteen out of the original 20 were successfully contacted and interviewed, while replacements were found for the remainder from the same or adjoining villages. The interviewer was the same as for the previous survey.

For the extensive survey, questionnaires were conducted in seven areas near Chivuna. These were Kataba and Maunga in Mazabuka District and Kaumba, Lweeta, Mujika, Njola and Ntambo in Monze District. Their relationship to Chivuna is shown in Map 2. It had been hoped to conduct further surveys of this nature in Momba, Nkonkola and Nanchengwa but transport difficulties prevented this.

Ten farmers were interviewed from each area, except Mujika, where only eight were obtained in the time available. The surveys were based on the 1973–74 storage season. Local agricultural camps were used as a base from which to operate, an extension officer from the camp acting as interpreter. They were undertaken over a period of two months from mid-March 1974.

Results

General information on farmers

Only 14 out of the 88 farmers interviewed in 1973 and 1974 were over 60. Of these 14 only 2 lived in the project area. The ages of the remaining farmers were divided almost equally between 21 and 40 and 41 and 60.

The family unit which a farmer was responsible for feeding comprised, on average, 8–13 people consisting of himself, his wives (normally one or two), his children, a relative and sometimes children of relatives. To this number would occasionally be added any friends or other relatives temporarily resident.

A farmer's food consisted typically of nshima, plus a relish. Nshima is a white paste produced from pounding maize into a flour which is then cooked with water. The basis of the relish is often vegetables. Other relishes mentioned were meat, groundnuts, fish, and insects (caterpillars and termites). More occasional foods were milk, porridge and sorghum. 'A meal of nshima and relish is normally eaten at least once a day unless the family is short of food or the women are very busy or on urgent work; and if food is plentiful twice' (P. Whitby 1972). Beer is consumed regularly by many small Zambian farmers and its brewing plays an important part in Zambian rural life.

Although nearly all farmers had lived all their lives in the same district, many, particularly in the project area, had moved the site of their farm during the last 15 years.

Most farmers had received some primary education and a third in the project area had been given some agricultural training, mainly at the local agricultural training centre. Courses mentioned included cotton production, pig rearing, cattle management and maize production. Seventy five per cent of farmers said that they received regular visits from the agricultural extension officer at an average of about twice a month — Intensive survey 1972–73 (Int. 1972–73).

In the project area 7 of the 20 farmers questioned in 1974 did some work other than farming. This proportion was considerably higher than in the surrounding districts where only 8 out of the 68 farmers practised other occupations. Most of the jobs mentioned could be taken up when farming work was slack. These included pottery, basket making (for stores), bricklaying, dealing in poultry or cattle, and carpentry.

About 1 in 6 farmers used, or had used credit, in operating their farm, mainly to buy fertilizer.

Crops and cattle

The range of crops grown by farmers is shown in Table 1. This was similar throughout the areas surveyed, except in Njola, where cotton and sunflowers were important.

TABLE 1

Chivuna: crops grown in 1973

	Crop	Farmers In project area No.	Per cent*	In extensive survey area No.	Per cent*
Food	Maize	20	100	68	100
	Groundnuts	20	100	63	93
	Peas/beans	6	30	27	40
	Sorghum	3	15	3	4
	Millet	0	0	1	1
	Sweet potatoes	2	10	0	0
	Vegetables (unspecified)	2	10	0	0
	Yams	0	0	1	1
Non-food	Tobacco	1	5	0	0
	Cotton	0	0	9	13
	Sunflowers	2	10	10	15
	Sunnhemp	1	5	4	6

*Percentage of total number of farmers surveyed

After maize, groundnuts were easily the most commonly stored crop. Others were peas/beans and, by the few farmers that grew them, sunflower, sunnhemp and sorghum.

Most farmers sold some proportion of their crops, although it is unlikely that, with the possible exception of cotton, any were grown mainly for this purpose.

In addition to their crops virtually all farmers in the project area kept cattle (cows and/or oxen) and some also kept chickens. The oxen were used for ploughing, while cows were employed mainly for breeding and sale, but also to pay fines imposed at village level. Only 3 farmers out of 18 regarded their animals as a source of food (milk). To a considerable extent cows are kept as a stock of wealth to be used as a kind of bank deposit and drawn on when need arises, such as crop failure. Most farmers possessed up to 12 cows — the maximum number recorded was 28.

Maize

The main factor determining the amount of maize grown by farmers was the needs of their family. However, five farmers mentioned the possibility of sale as a circumstance in which they would grow more, one saying that a higher price would be an incentive (Int. 1972–73). Table 2 shows the types of maize grown.

TABLE 2

Chivuna: types of maize grown in 1973

Type/variety	Farmers In project area No.	Per cent[a]	In extensive survey area No.	Per cent[a]
SR52	14	70	45	66
Hybrid other than SR52[b]	0	0	3	4
Hybrid (once grown)	0	0	2	3
Hickory King	8	40	22	32
Local	6	30	10	15

(a) Percentage of total number of farmers surveyed
(b) Kenya yellow, SR11 and SR13

The numbers in the table sum to more than the total number of farmers interviewed since some grew more than one type of maize. Farmers growing the SR52 variety said that they used new seed and 80% that they planned to increase its acreage (Int. 1972–73). Whereas hybrid maize seed was invariably bought, HK and local type maize seed were usually taken from the store. Occasionally, maize to be used as seed was stored separately, but normally it was selected from that already in the store.

Details of the method of planting maize, the tools used and the extent to which fertilizer (organic and inorganic) and insecticide were employed are given in Appendix B. Not surprisingly, greater attention was given to a crop of SR52 than to either local or HK maize.

Storage

Very little time usually elapsed between the harvesting of a farmer's maize and its movement into store, both normally taking place within the period May to July.

All farmers, except two visited during the extensive survey, stored their maize on the cob although two others, also from the extensive survey, took their remaining maize out of their stores before the end of the season and shelled it. Only one farmer, again visited during the extensive survey, stored maize without husks.

Table 3 shows the types of maize stored by farmers during the 1973–74 storage season.

Table 3

Chivuna: type of maize stored 1973–74

Type/variety	Farmers In project area No	Per cent	In extensive survey area No	Per cent
Hybrid	8	40	38	56
Local	2	10	7	10
Hickory King	8	40	20	29
Mixed Hybrid and Local	2	10	2	3
Mixed Hybrid and Hickory King	0	0	1	2
Total	20	100	68	100

The proportion of farmers storing different types of maize was similar in both surveys. The preference of farmers for storing local or HK maize rather than hybrid maize is illustrated by the fact that of the 22 growing hybrid plus another type only 4 elected to store only the hybrid. (A further 5 farmers stored a hybrid together with another).

Table 4 shows the quantities of maize put into store. Apart from the quantities put into the main store, some farmers are known to put aside smaller additional amounts for specific purposes such as for brewing beer or for seed. The quantity of grain stored by two farmers in the extensive survey area has been converted to cobs by multiplying by a factor of 2.5.

Table 4

Chivuna: quantities of maize stored 1973–74

Bags of cobs	Farmers			
	In project area		In extensive survey area	
	No	Per cent	No	Per cent
Under 20	1	5	6	9
20–29	5	25	17	25
30–39	5	25	24	35
40–49	5	25	13	19
50–59	–	–	1	2
60–69	2	10	3	4
70 and over	2	10	4	6
Totals	20	100	68	100

Note: – Nil

About 75% of farmers stored between 20 and 50 bags of cobs. Although, on the sample of farmers taken, the quantity of maize stored was slightly higher in the project area this difference was not appreciable. The majority of farmers storing less than 20 bags of cobs would not have had sufficient maize to last until the next harvest.

Storage facilities

Most farmers had either one or two stores. In the areas covered by the extensive survey one was the more common. The three main types: vertical timber poles made from branches plus a thatch roof (timber, poles and thatch); a woven basket plus a thatch roof (woven basket and thatch); and Kimberley bricks plus a thatch roof have been described in Part 2 (p. 35).

Farmers collected most of their materials for building their stores from the bush; the only items bought were cement, used in making the foundations of the brick stores, and sometimes bricks or baskets bought from other farmers. The most common month mentioned for building was May, followed by June. A farmer would often be helped in the construction by his wife, and occasionally by his children or relatives.

The time taken to collect the materials for a store and build it varied with its type. Estimates for those made of timber, poles and thatch varied between 3 and 10 days. Those of a similar type constructed at Mt. Makulu (Part 4 p. 62) took 3–4 days, but these were smaller than most of those built by farmers. The two estimates obtained for the woven basket type of store were 2 and 3 days respectively. These times are lower than might be expected but are, at least, partially accounted for by the fact that in each case the basket forming the body of the store had been bought. In the case of the stores made of Kimberley brick the period of construction, including that for moulding the bricks, varied between 4½ and 8½ days. Two farmers gave estimates below 4 days, but each had bought the bricks which they used.

Table 5

Chivuna: types of stores owned by farmers 1973–74

Type	Farmers			
	In project area		In extensive survey area	
	No	Per cent	No	Per cent
Woven basket and thatch	2	8	33	48
Timber, poles and thatch	10	40	25	36
Kimberley bricks and thatch	13	52	8	12
Other types	0	0	3a	4
Totals b	25	100	69	100

Notes: (a) Reed stalks and thatch; timber poles, chicken wire and thatch; and a woven basket type store on a brick base

(b) Some farmers had stores of more than one type

Table 5 summarises the number of stores of each type mentioned by farmers. It will be noticed that the most common type of store in the project area was made of Kimberley brick, while in the surrounding districts the woven basket type of store predominated. This may reflect the fact that the brick store was introduced by the Department of Agriculture and that farmers in the area covered by the intensive survey were more exposed to extension than at least some of those elsewhere.

The overall result shown for the extensive survey masks a wide variation in the types of store built in the different areas. Table 6 provides this breakdown.

Table 6

Chivuna extensive survey: types of stores owned by farmers by area 1973–74

Area	Type			
	Woven basket & thatch	Timber poles & thatch	Kimberley bricks & thatch	Others
Kataba	8	2	0	0
Maunga	1	6	1	2
Kaumba	7	3	1	0
Lweeta	10	0	0	0
Mujika	1	4	2	1
Njola	1	6	3	0
Ntabo	5	4	1	0
Totals all areas	33	25	8	3

In three areas — Kataba, Maunga (both in Mazabuka district) and Lweeta — woven basket stores were the most widely used and in Maunga no other kind was met. In three other areas — Kaumba, Mujika and Njola — timber and pole stores predominated. Few farmers used bricks and only in Mujika and Njola did more than one farmer have a store of this type. It is difficult to know to what extent these differences are real in view of the small number of farmers supplied. However, what does emerge is that there is no one type of store which is most common in all areas.

During the 1973 intensive survey farmers were asked whether they had ever considered changing their method of storage. Although some had made changes in the past, the majority were satisfied with their existing technique and only four had considered any change — from the timber pole type of store to that of brick. Details of farmers' expectations of the lives of different types of store and of the lives of their existing ones are shown in Tables 7 and 8. Since these are based on the memories and opinions of farmers they can be taken only as a rough guide.

Table 7

Chivuna: expected lives of stores owned by farmers 1973–74

	Timber Poles, Thatch		Woven Basket, Thatch		Kimberley Bricks, Thatch	
Years	No	Percentage of total	No	Percentage of total	No	Percentage of total
1	1	2	0	0	0	0
2	1	2	1	2	0	0
3	2	5	6	12	0	0
4	9	22	10	20	0	0
5	3	7	8	16	7	27
6	1	2	7	14	1	4
7	2	5	3	6	0	0
8	7	17	9	18	0	0
9	2	5	0	0	1	4
10	6	15	2	4	7	27
11	0	0	0	0	1	4
12	0	0	3	6	1	4
Over 12	3	7	1	2	3	12
Not known	4	10	1	2	5	19
Totals*	41	99	51	102	26	101

*Due to rounding, percentages do not sum to one hundred

Table 8

Chivuna: age of existing stores owned by farmers 1973–74

	Timber Poles, Thatch		Woven Basket, Thatch		Kimberley Bricks, Thatch	
Years	No	Percentage of total	No	Percentage of total	No	Percentage of total
0	1	2	0	0	1	4
1	5	12	2	4	4	15
2	9	22	12	24	1	4
3	7	17	12	24	2	8
4	1	2	3	6	4	15
5	6	15	12	24	7	27
6	2	5	4	8	2	8
7	1	2	1	2	1	4
8	2	5	1	2	0	0
9	0	0	0	0	1	4
10	2	5	0	0	0	0
11	0	0	0	0	0	0
12	1	2	3	6	0	0
Over 12	2	5	1	2	1	4
Not known	2	5	0	0	2	8
Totals*	41	99	51	102	26	101

* Due to rounding, percentages do not sum to one hundred

The timber poles and thatch stores were expected to last generally up to 10 years and few farmers gave the age of those they were using at higher than this. The reason for their comparatively long life is probably the fact that their parts are being constantly replaced, so that by the time they are finally discarded only the basic framework is the original.

Both the expected life and the age of the woven basket stores were slightly less than that of the timber, pole and thatch type and over 80% of those in use were estimated to be less than six years old. As would be expected the Kimberley brick stores were estimated to have the greatest longevity and none were anticipated to last less than five years. The ages given for existing stores of this type is likely to reflect their comparatively recent introduction as much as their potential life.

Usage of stored maize

Maize is usually taken out of store by a farmer's wife and, in cases where he has more than one spouse and his harvest is sufficient, the normal pattern is for each wife to be allotted a store, so that maize is taken from each simultaneously. However, this is not always the case and at least two farmers finished the maize in one of their stores before starting another. The method of removing maize was almost invariably from a side door near the top. Most farmers took out regular amounts ranging from a tin (about a sixth of a 90 kg bag) to a bag, weekly or fortnightly.

The time when maize was first removed from the store was, on average, earlier in the case of farmers in the project area, and 75% of them started using it in May or June. In marked contrast, only two farmers visited during the extensive survey did this and in all areas, except Maunga, the majority did not commence removal until August at the earliest. Farmers in the extensive survey area also finished their maize earlier, on average, than those in the intensive survey, showing that generally they had maize in store for a shorter period. The reasons for this are probably the slightly greater number of people which these farmers were responsible for feeding and the slightly smaller quantities of maize that they put into store. Table 9 shows the purposes for which farmers used their maize.

Table 9

Chivuna: usage of stored maize by number of farmers 1973–74

Usage	Farmers			
	In project area		In extensive survey area	
	No	Per cent*	No	Per cent*
Food	20	100	68	100
Brewing beer	16	80	14	21
Gifts	11	60	37	54
Barter	10	50	7	10
Seed	7	35	17	25
Sale	5	25	21	31
Feeding animals	0	0	5	7
Payment of wages	0	0	3	4
Repayment of loans	0	0	1	2

* Percentage of total number of farmers surveyed

Despite the fact that no farmer in the intensive survey mentioned using his maize to feed animals it is likely that this practice took place, since farmers are known to use the cores of shelled cobs to feed their cattle and to give their chickens damaged grains. A farmer's dog may also be fed with the remnants of a meal of nshima. Another difference between farmers in the project area and those in the surrounding districts was the greater percentage of the former who used their maize to brew beer and for barter. It is possible that these two uses may be connected, with farmers bartering some of the beer which they make. It is also possible that the brewing of beer in the extensive survey area was more pronounced than the survey results show, since some farmers or interviewers may not have always been willing to admit the practice.

Farmers were also asked for an estimate of the amounts of their maize which they used for each purpose. Table 10 shows this data.

The greatest proportion of farmers' maize was used as food and in the project area all farmers giving an estimate put this at over 80%. Surprisingly, the results of the extensive survey showed that 26% of farmers visited used less than this proportion of their maize in this way.

Beer was made by farmers to sell as well as for their own consumption and in some cases, particularly where the maize concerned was in poor condition, this form of trade in maize would be more profitable than selling the grain. Amounts used ranged up to 16 bags or 40% of the total stored.

The making of gifts was a third important usage of maize, but it is possible that some gifts were really barter transactions, especially in the case of the extensive survey area farmers. A common object of barter was to obtain meat and, since no farmer mentioned bartering during the visits made for sampling, it is likely that this takes place mainly at the beginning of a storage season when farmers had most maize to spare. Some gifts would also have been made at the beginning of the storage season, but others would be made later, mainly to relatives whose own stores were empty. The normal amount of maize used to make gifts or barter was up to two bags.

Farmers sell most of their surplus maize before storage (see Marketing). Sales made from the store usually consist of only a few bags sold to neighbouring villagers. In the extensive survey area the proportion of maize used in this way was quite high and may have reflected a definite intention of some farmers to keep some back. No details of these sales were collected, but in Mujika at least one farmer kept a store of maize for sale in March or April.

Most of the farmers who used some of their stored maize for seed grew HK or local type. In the project area up to three bags were recorded as being used in this way, but one farmer covered in the extensive survey in Maunga estimated that he had used six bags.

In the 1973 intensive survey an attempt was made to ascertain the effects of a good or bad crop by asking which usages of maize would rise or fall in these circumstances. Ten farmers said that when they had a good crop they increased their making of beer. Another ten said that they increased their bartering, while four said that they sold more. In addition, nearly half of the farmers interviewed tried to retain some of their stored maize in case of a poor crop in the following year. Except in one case, farmers kept maize from the two years separate. In respect of a bad crop the most common reply (of nine farmers) was 'all usages except food'. Five said that if they had less maize they would reduce the amount they made into beer.

A farmer may buy maize if his own is insufficient and in the 1973–74 storage season this was done by five farmers in the project area. The maize may be bought either as shelled grain from other farmers or friends, or as maize meal from the local store. Apart from being used directly as food, maize is bought by some farmers to make into beer for selling.

In the extensive survey area only 2 out of the 68 farmers bought any maize for food. This was a much smaller proportion than in the project area and may be explained by the greater extent to which stored maize was estimated to have been used to make gifts.

Table 10

Chivuna: usage of maize by percentage of total stored 1973–74

Food

Percentage	Farmers: In project area No	Farmers: In project area Per cent	Farmers: In intensive survey area No	Farmers: In intensive survey area Per cent
Up to 50	0	0	1	2
51–60	0	0	6	9
61–70	0	0	7	10
71–80	0	0	12	18
81–90	10	50	13	19
91–100	8	40	26	38
Not known	2	10	3	4
Totals	20	100	68	100

Making beer

Percentage	Farmers: In project area No	Farmers: In project area Per cent	Farmers: In extensive surveyarea No	Farmers: In extensive surveyarea Per cent
1–5	6	38	4	29
6–10	5	31	2	14
11–15	3	19	3	21
16–20	0	0	1	7
21–25	0	0	1	7
26 and over	0	0	2	14
Not known	2	13	1	7
Totals	16	100	14	99

Gifts

Percentage	Farmers: In project area No	Farmers: In project area Per cent	Farmers: In extensive survey area No	Farmers: In extensive survey area Per cent
1–5	8	73	11	30
6–10	1	9	13	35
11–15	0	0	7	19
16–20	0	0	0	0
21–25	0	0	2	5
26 and over	0	0	2	5
Not known	2	18	2	5
Totals	11	100	37	99

Sale

Percentage	Farmers: In project area No	Farmers: In project area Per cent	Farmers: In extensive survey area No	Farmers: In extensive survey area Per cent
Up to 10	4	80	9	43
11–20	1	20	6	29
21–30	0	0	5	24
Over 30	0	0	1	5
Totals	5	100	21	99

Seed

Percentage	Farmers: In project area No	Farmers: In project area Per cent	Farmers: In extensive survey area No	Farmers: In extensive survey area Per cent
Up to 1	0	0	0	0
2–4	5	71	8	47
5–7	1	14	5	29
8–10	0	0	2	12
11 and over	0	0	1	6
Not known	1	14	1	6
Totals	7	99	17	100

Barter

Percentage	Farmers: In project area No	Farmers: In project area Per cent	Farmers: In extensive survey area No	Farmers: In extensive survey area Per cent
Up to 1	1	10	0	0
2–4	8	80	3	43
5–7	0	0	2	29
8 and over	0	0	1	14
Not known	1	10	1	14
Totals	10	100	7	100

Note: Due to rounding, some percentages do not total one hundred

Marketing

Farmers are encouraged to sell maize surplus to their requirements as soon as possible after harvest in order that it may be known whether the country has any for export or requires to import. The amount of a farmer's crop determines whether he sells any maize at this time and in the 1973–74 season only 11 farmers in the project area were able to sell compared with 17 in the previous year. There was also a big reduction in the quantities sold between the two years. Even without encouragement it is likely that most farmers would sell their maize soon after harvest due to the need for cash, and reasons quoted by them for selling when they did, mostly in June and July, included: needs of family; in order to buy materials for farming, and to pay for childrens' schooling.

Sales are almost invariably made to the NAMBoard, either at a 'line-of-rail' or a local rural depot. A standard price is paid throughout the season so that there is no incentive to put off sales in anticipation of higher prices. There is financial inducement to deliver maize to the line-of-rail depot in the form of a higher price — K4 30 per bag as opposed to K4 00 during the 1973 intake season — but only 2 farmers out of 11 transported it the extra distance. The normal mode of transport used to the local depot was an ox-drawn scotch cart. The two farmers delivering to the line-of-rail depot hired a lorry. Maize sold to NAMBoard is always in the form of shelled grain and is governed by a grading system laid down in the National Agricultural Marketing (Acceptance Standards) Regulation of 1970 (Table 33). Three grades of maize exist, (A, B, C); in practice 90% of that delivered is Grade A and nearly all of that sold by the farmers in the survey was of this standard.

The number of farmers visited in the extensive survey who had sold maize varied appreciably from area to area. In the Mazabuka District 19 out of 20 farmers made sales, but in three of the Monze areas — Lweeta, Kaumba and Ntambo — less than half did so. The quantity concerned varied from a few bags to over a 100, but 75% of farmers sold less than 60 bags.

Losses

In the 1974 intensive survey 17 out of the 20 farmers reported damage to their stored maize. Some of these replies may have been prompted by the periodic visits paid to them by someone assessing losses, but the number of farmers covered in the extensive survey who reported damage was also high at 90%.

Farmers realised that insects were the main cause of the damage to their maize. Rats were also mentioned by seven farmers covered in the extensive survey and three mentioned mould.

December was the month most frequently given as the time when most damage occurred. This applied to replies received in both the project and surrounding areas. Other months which were often mentioned as the occasion of most damage were September, October and November, while other months given ranged from July 1973 to April 1974. The reason why pre-December months predominated in replies may have been that some respondents are believed to have interpreted the question as 'When did you first notice that your maize was damaged?'

All farmers in the project area, except one, gave low estimates of the degree of damage that occurred — up to a maximum of 2½ bags per store or less than 5% of the total. Table 11 shows the results of the same question put in the extensive survey.

Losses of 10% or under were recorded by over 80% of the responding farmers storing local maize, by 75% of those storing HK type, and by 55% of those storing SR52. The trend towards increased loss in the case of SR52 maize is apparent and will be referred to in Part 4. It is also relevant that out of all the responding farmers but excluding 'don't knows', 20% reported no loss, 45% losses of 5% or less, and 66% losses of 10% or less. Some of the very high losses reported were obviously misunderstandings but have been included in the over 20% category. For most farmers these

Table 11

Chivuna extensive survey: farmers' estimates of damage to maize by percentage of total stored 1973–74

%	Type/Variety			
	Local	HK	SR52	Total
0	2	5	4	11
1–5	2	2	9	13
6–10	1	4	6	11
11–20	0	2	8	10
Over 20	1	1	6	8
Don't know	2	5	8	15
Total	8	19	41	68

percentages represented up to 3 bags of cobs but for five farmers, if correct, they represented 10 or more bags. Four of these five stored SR52.

The most common usage of damaged maize was for feeding to the farmer's animals (chickens and cattle). It was also reported as being used for making into beer and for consumption as food; the extent to which the latter happens will depend on the sufficiency of a farmer's stored crop and its degree of damage. Only two farmers, in Njola and Ntambo respectively, said that they threw their damaged maize away, so this practice is obviously unusual.

Section D at the end of this part of the report assesses the extent to which the questionnaire approach was found to be a useful method of assessing loss.

SURVEYS IN CHALIMBANA

Procedure

In August 1973 intensive questionnaires were put to 12 farmers in the villages of Kapamangoma and Mukankaulwa near Chalimbana. The attempt to see the same farmers in 1974 was largely unsuccessful, since many had either left the area or were away from home on each occasion their farm was visited. It was also difficult at that time to find a sufficient number of farmers who had stored maize, since many had suffered from a poor harvest. These problems had three results: the number of farmers interviewed was reduced from 12 to 10; four farmers had to be selected from Kabeleka, the village adjoining Kapamangoma, and only three farmers were visited in both years.

Other factors to be noted in interpreting the survey results are that different extension officers assisted in 1973 and 1974, and that their proficiency in English was not as high as was desirable. In the 1974 survey illness to an officer resulted in a replacement having to be found, so that the high degree of standardisation needed in putting questions and interpreting answers may not have been achieved. Despite these problems it is thought that the survey results do give useful information on the storage patterns in this area, but are probably not so accurate in detail as those for Chivuna.

Extensive questionnaire surveys were conducted in four districts near Chalimbana: in Chinyunyu, Luimba, Nyangwenya and Shilling (Map 3). Ten farmers were taken from each area, the interviews taking place in April and May 1974. The method of choosing farmers was the same as that used in the extensive survey around Chivuna.

Results

General information on farmers

The average size of the family unit in the project area was nine or ten, including the farmer himself. In the extensive survey areas it was slightly larger, except in Nyangwenya.

The diet of farmers was similar to that in Chivuna but the consumption of meat was mentioned less frequently.

A number of the farmers visited had previously lived in other districts. This applied to nearly 50% of those in the extensive survey area and included four farmers who had come from Rhodesia. It is likely that at least some of these farmers would not have absorbed the traditions and agricultural practices of their new area. In the 1973 intensive survey only 2 of the 8 farmers stated that they had previously lived elsewhere. However, due to the proximity of Lusaka it is probable that some movement into and out of the town takes place.

Nearly all farmers visited in the project area in 1973 had received some primary education. With the exception of Chinyunyu, where the position was similar, this was higher than in the surrounding districts where the proportion was about 50%.

Over half of farmers in the project area had received some agricultural training, but only two of those seen in 1974 had attended a course in the past year. Two-thirds of farmers received 'regular' visits from an extension officer (Int. 1972–73), but the frequency mentioned most often was only two or three times per year.

Just under half of the farmers covered by the intensive surveys sometimes worked out-side farming in such capacities as part-time driver, fire ranger, bricklayer, mill worker and labourer (harvesting) for a large scale farmer. In the extensive survey areas the number undertaking such outside work varied — in Luimba and Chinyunyu half or more of farmers had outside occupations, while in Nyangwenya and Shilling together only one farmer did such work.

None of the 10 farmers visited in the project area in 1974 had used credit to assist their farming activities, but 4 of the 12 visited in 1973 had done so. Eight of the 40 farmers visited for the extensive survey had used credit, 5 of these were in the Chinyunyu area.

Crops and cattle

Table 12

Chalimbana: crops grown in 1973

Crops		Farmers			
		In project area		In extensive survey area	
		No	Per cent*	No	Per cent*
Food	Maize	10	100	40	100
	Groundnuts	3	30	24	60
	Sorghum	1	10	18	45
	Millet	1	10	0	0
	Peas/beans	0	0	8	20
	Sweet potatoes	0	0	3	8
	Pumpkins	0	0	3	8
	Melons	0	0	1	3
	Vegetables (unspecified)	8	80	1	3
Non-food	Sunnhemp	0	0	2	5
	Cotton	0	0	1	3
	Sunflower	0	0	1	3

* Percentage of total number of farmers surveyed

Table 12 shows that the range of crops grown by farmers visited in 1974 in the project area was more limited than those either in the surrounding districts or in Chivuna. However, it is probable that some of these farmers grew such vegetables as peas/beans, sweet potatoes and pumpkins, but did not think to mention them specifically. Also, when the project area was visited on the first occasion in 1973 three farmers said that they had grown sorghum the previous year.

Due to the poor harvest few farmers in the project area sold any of their crops in 1973, though 70% of extensive survey farmers had done so. The types of crops sold and stored by farmers in Chalimbana were the same as in Chivuna. A difference between the two areas was that fewer farmers in the Central Province possessed their own cattle and, therefore would have had to hire or borrow oxen which they needed.

Maize

Factors determining the quantity of maize grown were family needs, the availability of implements and possibilities of sale. These factors were each mentioned by five farmers. Greater availability of fertilizer and improved seeds were seen as additional conditions under which more maize would be grown.

Table 13

Chalimbana: types of maize grown in 1973

Type/Variety	Farmers			
	In project area		In extensive survey area	
	No	Per cent[a]	No	Per cent[a]
SR52	4 (8)	40 (67)	12	30
Hybrid other than SR52[b]	0 (0)	0	5	13
Hickory King	0 (0)	0	0	0
Local	6 (5)	60 (42)	24	60

Notes: (—) 1973 figures
(a) Percentage of total number of farmers surveyed
(b) SR13, Kenya Yellow and ASA81

Table 13 shows the types of maize grown by farmers. Despite the results for the 1973 intensive survey it would seem that a slightly greater number of farmers grow local maize than grow a hybrid and only in one of the extensive survey areas — Luimba — was there a small majority the other way. As in Chivuna there appears to be a trend towards an increased use of SR52.

Tables showing the methods of planting maize, the tools used and the extent to which insecticide and/or fertilizer were applied are given in the Appendix. The means of obtaining hybrid (bought) and local (from last year's crop) were the same as in the Southern Province.

Eight farmers in the project area harvested their maize in May; two in June. Most left it in the field to dry, but a few brought it to their farm, where it was either put on the ground in a wood and wire enclosure or placed on a drying platform. Usually storage took place in August, with shelling being done by hand or with sticks. August was also the most common month for storage amongst farmers covered in the extensive survey. Two of these farmers used a tractor driven sheller for shelling their maize and one a hand operated (simple) sheller.

Storage

All farmers visited in the project area stored their maize in the form of shelled grain. Maize to be used as seed was stored separately. Needs of the family was the only important influence on the quantities stored. In the extensive survey areas storage of maize in grain form was usual but not universal. Overall, 75% of farmers practised it, but in Luimba the ten farmers visited were equally divided between storing grain and cobs. Of the 8 farmers in the extensive survey who stored cobs 5 did so with husks attached, 3 without. Table 14 shows the quantities of maize put into store by those farmers who were able to give estimates of this amount.

Table 14

Chalimbana: quantities of maize stored 1973–74

Bags (grain)[a]	Farmers			
	In project area		In extensive survey area	
	No.	Per cent[b]	No.	Per cent[b]
1–5	2	22	3	8
6–10	2	22	10	27
11–15	3	33	6	16
16–20	1	11	9	24
21 and over	1	11	9	24
Total	9	99	37	99

Notes: (a) Bags of cobs have been converted where necessary into shelled grain by dividing by 2.5

(b) Due to rounding percentages do not sum to one hundred

The quantities of maize put into store were slightly higher in the extensive survey area, particularly in Nyangwenya where 4 farmers put in more than 20 bags and only 2 less than 10.

Details of insecticide used by farmers are given in Part 4. There was a certain amount of dissatisfaction with DDT (not a recommended treatment), and a number of farmers who used it had considered changing to another insecticide (unspecified).

Storage facilities

Few farmers had more than one store and none more than two. Most of those storing grain had timber stores ie non-brick stores, muddied inside and out. In the project area the woven basket type of store is thought to have been the most common although, since all stores were muddied it is not possible to say for certain. Three of the ten farmers visited there had stores muddied on the inside only. In the Chinyunyu area four farmers used a brick store for their grain and another had a timber store with a tin roof. Occasionally, compartmentalised stores were encountered with some compartments being used for seed.

There was no uniform method of storing cobs and, as well as the more conventional materials, chicken netting, small poles, sorghum stalks and grass were also used in their construction. Grass was only used in a temporary structure.

Materials for building stores were obtained, as in Chivuna, mainly from the bush. These were usually carried back to the farm on a farmer's shoulders (or his wife's) but in a few cases a scotch cart was used. Estimates of the time taken for collection, building and mudding stores varied appreciably between 3 and 11 days, the data on this being less detailed than was able to be obtained in Chivuna.

Most stores were built within the period May to August, July being the most popular month. Little can usefully be said about their longevity without knowing the exact type of individual stores. The majority of timber stores were estimated to be less than 4 years old and few were expected to last more than 6 years. The most frequently quoted life expectancy by farmers in the project area was 3–5 years, and by those covered in the extensive survey 2–4 years.

Usage of stored maize

Nearly all farmers removed maize from their stores at regular intervals, and of those in the project area most started using their maize between July and September within two months of it entering the store. Half of these farmers took amounts out weekly. Of the remainder two removed maize twice a week, two monthly and one at irregular intervals. The farmer with two stores finished the maize in one before starting on another. Although one farmer said that he took out a quantity equivalent to 8 tins of maize per week the normal amount was 1 or 2 tins.

Most of those farmers who stored grain took it from the side of the store, but the 'door' might be either near the top or the bottom. These methods were about equally common. A few farmers also took grain from the top by lifting off the roof, or from a hole underneath the store. Those farmers storing cobs drew these either from the top of the store or from a side door near the top.

Of the farmers in the project area two still had some maize in their stores at the time of conducting the 1974 intensive questionnaire in mid-May. Three others had just finished it. The remainder stated that they had finished their maize at some point between November and March, all except one mentioning the last three months of this period.

In the extensive survey area August was the month quoted by most farmers as the time when they first started using their stored maize. It was followed by October, July and September. Two-thirds of these farmers finished their maize in April or later, the others mainly between December and March. Tables 15 and 16 show the purposes for which farmers used their maize and the proportion of their stored crop which was used for each purpose.

The fact that farmers in the project area used their maize for more limited purposes than those covered in the extensive survey may reflect the slightly lower quantities of maize they put into store. It may also reflect the quality of different interviewers with some of those conducting the extensive survey being able to draw out more detailed information from farmers. Additionally, as noted earlier (p. 00) some maize would almost certainly have been fed to animals despite the fact that no farmer mentioned this.

The quantity of maize used for making beer was estimated by most farmers to have been just one bag. It is surprising that the proportion of farmers in the extensive survey who mentioned using their maize in this way was as low as 23%, and this may be an understatement in view of the importance of this activity in village life.

Table 15

Chalimbana: usage of stored maize by number of farmers 1973–74

Usage	Farmers: In project area		In extensive survey area	
	No.	Per cent[a]	No.	Per cent[a]
Food	10	100	39	100[b]
Making beer	6	60	9	23
Seed	0[c]	0[c]	12	31
Feeding animals	0	0	10	26
Gifts	0	0	8	21
Sale	0	0	4	10
Barter	0	0	2	5
Payment of wages	0	0	1	3

Notes: (a) Percentage of total number of farmers surveyed

(b) One of the 40 farmers had no maize to store

(c) In the project area seed was often put in a separate store

Table 16

Chalimbana: usage of maize by proportion of total stored 1973–74

Food					Making Beer				
	Farmers					Farmers			
Percentage	In project area		In extensive survey area		Percentage	In project area		In extensive survey area	
	No.	Per cent	No.	Per cent		No.	Per cent	No.	Per cent
Up to 50	2	20	3	8	1–5	1	17	3	33
51 to 60	1	10	2	5	6–10	3	50	3	33
61 to 70	1	10	5	13	11–15	0	0	1	11
71 to 80	0	0	6	15	16 and over	2	33	1	11
81 to 90	0	0	2	5	Not known	0	0	1	11
91 to 100	6	60	19	49					
Not known	0	0	2	5					
Totals	10	100	39	100		6	100	9	99

Farmers in extensive survey area only								
Seed*			Feeding Animals*			Gifts*		
Percentage	No.	Per cent	Percentage	No.	Per cent	Percentage	No.	Per cent
1 or less	0	0	1–10	4	40	1–5	2	25
2–4	1	8	11–20	1	10	6–10	3	38
5–7	2	17	21–30	2	20	11–15	1	13
8–10	4	33	31–40	1	10	16 and over	1	13
11 and over	3	25	41 and over	1	10	Not known	1	13
Not known	2	17	Not known	1	10			
Totals	12	100		10	100		8	102

Note: *No farmer in the project area mentioned using maize for this purpose

Due to rounding, some percentages do not total one hundred

The amount of maize used in making gifts was, normally up to three bags. Two of the farmers selling maize from their stores sold more than 20 bags. The absence of either of these activities from the list of usages of maize in the project area is probably the result of the poor harvest experienced by many farmers. As in Chivuna, another effect of a poor harvest was said to be a reduced making of beer.

Six of the ten farmers in the project area supplemented their own supply of maize with purchases, either in the form of meal from the store in Chalimbana, or of shelled grain bought from other farmers or villagers. A seventh farmer, whose maize was finished in February, was helped with gifts of food from his relatives. In the same way as in Chivuna one half of farmers tried to counteract a bad harvest by retaining some of their maize from one year to the next, but did not mix maize from the two years together in their stores.

Marketing

The pattern of marketing maize was the same as that already outlined for Chivuna. In the project area in Chalimbana only one of the ten farmers had sold any maize in 1973, and even in this case the amount concerned was very small — two tins to a friend. This was in marked contrast to the previous year when 8 of the 12 farmers interviewed had sold maize with four selling over 100 bags each. It was also in contrast to the situation in the extensive survey area where 60% of farmers had sold maize, mainly to the NAMBoard. Except in three cases these sales were classified as

Grade A. Where sales were made other than to NAMBoard — to local traders or fellow farmers — the quantities involved were smaller, and no farmer had sold more than 20 bags in this way.

Losses

About two-thirds of the farmers interviewed for both the intensive and extensive surveys said that their maize had shown signs of damage. This damage was attributed mainly to insects, and some farmers mentioned weevils. A few farmers also mentioned rats.

It is unlikely that many farmers in the project area fully understood the implications of a question about the period when the greatest damage occurred. In 1974 most answered immediately or soon after their maize entered the store, whereas in 1973 the period most often mentioned was March/April. Opinion amongst the extensive survey farmers on this point was fairly uniform with 18 (two-thirds of those answering) giving the rainy season — December to February. October and August were the only other months to be mentioned more than once.

Only 3 of the 6 farmers with whom the intesive survey was conducted in 1974, and who reported damage, were able to give estimates of its extent. Estimates were provided in percentage terms: 25% (representing 11 bags) in the case of a farmer storing SR52 and 50% (8 bags) and 100% (3 bags) for two farmers storing local type maize. Of the estimates of loss made by farmers in this area in 1973 5 of the 6 made by those storing SR52 were of proportions up to 25% of their stored crop (up to 4 bags) and one 'more than 50%' representing over ten bags. A farmer storing local type maize put his damage at less than half a bag. Apart from damage to maize which they stored for food, three farmers also stated that the maize they stored for seed had also been damaged.

Estimates of the extent of damage given by farmers in the extensive survey area varied appreciably between Luimba and Nyangwenya on the one hand, and Shilling and Chinyunyu on the other. In the first two areas estimates of both cob and grain damage were relatively lower, mainly between a half and two bags. Only 1 of the 13 farmers concerned who stored SR52 in grain form, put his damage at above 20%. In Shilling and Chinyunyu assessments were usually given in percentage terms, and the range of damage was much higher — from 50 to 100% representing up to 19 bags of maize. In Chinyunyu the interpreter consistently suggested a possible figure of loss (75%) with the question. Not surprisingly, farmers picked this up thinking it to be the desired answer and 6 out of 7 gave this as their reply. In Shilling three farmers put their damage at 100%, one at 75% and one at 50%. In none of the four areas was there any tendency for the estimates of damage to one type of maize to be noticeably higher than to the other.

The two main uses of damaged maize were for food and animal feed. Brewing beer or throwing maize away was mentioned only by a very few farmers.

EXTENSIVE SURVEYS — CONCLUSION

Some differences in behaviour did exist between farmers in the project and surrounding areas, such as the fact that in Chivuna the woven basket type of store was more commonly used than the findings of the intensive survey suggested. Also, in Chalimbana differences arose because most farmers in the extensive survey area experienced a better harvest. However, taken overall the results of the extensive surveys did not reveal any marked divergence between the storage pattern of the farmers visited compared with that of farmers in the project area.

ASSESSMENT OF LOSSES USING A QUESTIONNAIRE

Problems

An initial problem of using the questionnaire approach to obtain an assessment of loss is that of definition. Because of the subjective nature of loss an agreement on this must be reached between the interviewer and the farmer. This can be particularly difficult where interpreters have to be used. Another problem where interpreters are being employed is that of the suggested answer. As just noted, this occurred in the Chalimbana extensive survey. Leading by an interpreter in this way is usually noticeable because of the consistent and short answers given by respondents. Further difficulties are raised in the interpretation of replies in regard to the assessment of the magnitude of loss. When these are given in terms of quantity, they have to be compared with the total crop in store if it is wished to obtain a percentage figure. This amount may not be easy to obtain nor, when obtained, very reliable. Also, since a store is normally being emptied gradually the question arises of whether any percentage loss quoted by a farmer reflects this movement or simply the amount of loss at the time when the question is put. When respondents are asked for a proportional figure of loss instead of a quantity interpreter bias may increase. A significant limitation of the questionnaire approach is present in regard to the agents causing losses. It was found that farmers were aware of the most important agent and of subsidiary agents but, without sampling, it is difficult to attribute a proportion of the loss to these individually. This is necessary if suitable control measures are to be introduced.

A further problem in using questionnaires with the farmers in the present study was that they tended to become more aware of their losses when they knew that someone was investigating them. This may have been because they hoped to obtain more advice and free pesticides. This was noticed in the Chivuna intensive survey where four times as many farmers reported losses in 1974 as in 1973. It may therefore be wrong to explain to a farmer that information is sought on his losses so that they might be reduced — he may increase his estimate of loss to obtain help.

Analysis of results and conclusion

The farmers sampled regularly in Chivuna appeared to be worried only by losses at the end of the season. In Table 17 their estimates of losses are compared with those obtained by sampling (Part 5).

Table 17

Chivuna intensive survey: comparison of farmer and sample estimates of losses 1973–74

Farmer	Farmer estimate %	Sample estimate* %
A	2	1.7
B	<1	3.8
C	<1	3.0
D	3	5.7
E	?	5.0
F	10	3.3
G	?	3.5

Notes: ? no estimate obtained

* losses by store are given later in Table 31

There was obviously little tendency to exaggerate amongst these farmers, possibly because sampling had been carried out regularly and, in fact they underestimated the importance of their losses. If these findings are combined with those of the Chivuna extensive survey Table II they indicate the possibility of obtaining a farmer's estimate which should be within 5% of that obtained by measurement. For this purpose we have to assume that losses in the extensive survey area were similar to those in Chivuna at around 2–6%.

The questionnaire approach, if used carefully, may have some value if done on a large number of farmers in the area studied and coupled with a smaller detailed sample analysis programme.

Part 4

The measurement of losses

INTRODUCTION

The measurement of losses was undertaken in the following way:

Stores of various types were built at Mt. Makulu to simulate those constructed by farmers, and also to test the effect of alternative methods of storage. Control samples were placed in the individual stores which were then filled with maize which had been purchased from farmers.

Samples of maize were taken at regular intervals throughout the storage period, both from the simulation stores and from the stores of the selected farmers in the project areas. The amount and frequency with which maize was taken from the simulated stores was determined with a view to representing a farmer's pattern of consumption. The samples, and control samples were analysed.

The absolute measure of weight loss in the simulation stores was obtained by accurately measuring the amount of maize entering and removed from each. The loss was taken as the figure resulting from deducting the sum of the weights of individual removals from the weight of the maize originally put into the store.

Various techniques of assessing losses were tested by examining the relationship of the results they gave when applied to the samples taken from the simulation stores to the results obtained by weighing. A practical method for giving losses with reasonable accuracy and known errors was reached and then applied to the samples of maize taken from farmers' stores. Quality losses were assessed using a grading system.

This programme of research is now considered taking each step in turn. This part of the report concludes with an analysis of the use of insecticides both by farmers and in the Mt. Makulu stores.

THE SIMULATION STORES

The men who built the simulation stores at Mt. Makulu found it difficult to do so to the exact design specified since they were not from either of the areas surveyed, and some compromise was therefore necessary. The simulation stores were scaled down versions of farmers' stores. Sorghum stalks were used in place of wood poles for the walls of the cob stores and a hole was cut in the wall under the roof for emptying. Four cob stores were built, two for cobs with husks (C3 and C4) and two for cobs without husks (C1 and C2). The project team was told that in some parts of the country maize was stored on the cob without husks although in the limited survey undertaken this type of storage was rarely seen. However, an example of this was included in the simulation programme. The cob stores were raised 0.3m off the ground and were approximately 1.2m square with a volume of 1.6m^3. They had conical grass roofs. The traditional cob stores in the field were raised 0.4–0.6m off the ground, 1.4–1.6m high, 2.0–2.6m in diameter and with a volume of 4.9–8.3m^3. All had conical grass roofs.

It was not possible to build the Kimberley brick store for simulation purposes. Those from which samples were taken were approximately 1.6m high standing on a cement plinth raised on bricks between 0.05–0.25m off the ground. The diameter was 1.7–2.4m and the volume 3.1–7.1m^3.

Unfortunately despite the authors' efforts the simulation mud stores for grain were, unlike most of those in the villages, built of termite susceptible timber. As soon as this was realised the ground surrounding the support poles was thoroughly soaked with dieldrin but, nevertheless, two of the stores did become infested by termites. These stores were also damaged by wood borers.

The simulation stores for grain were built 0.3m above the ground, 1.3m high and 1.2–1.3m in diameter. Two stores, M2 and M3, had a volume of 1.5m^3 (6 x 90 bags) and three M1, M4 and M5, a volume of 1.9m^3 (7 bags). In comparison the stores studied in Chalimbana were 0.4–0.6m above ground, 1.2–1.7m high, 1.5–2.1m in diameter and 2.8–8.0m^3 in volume (mean 4.6m^3).

By the time sampling began in October 1973, following the first intensive questionnaire survey, none of the farmers' stores was full and some were less than half full. The removal of grain to represent consumption attempted to reconcile the amount in store with the pattern of usage by the farmer. However, one muddied store (M3), filled at the same time as the others, with insecticide — treated grain, was not opened until the beginning of February. This was to investigate how treated grain would keep as a reserve. Of the remaining stores two, M1 and M2, were emptied from the top and two, M4 and M5, from the bottom. Additionally, the grain entering stores M1 and M5 was treated with 'Blue Cross' which is a 1% malathion dust sold to farmers under the recommendation of the Ministry of Rural Development (pp 000 and 000).

For ease of reference the relationship between individual stores and the abbreviations used is now summarized.

Abbreviation	Type of store	Maize contained
C1 and C2	Timber, sorghum stalks and thatched roof	Cobs without husks
C3 and C4	Timber, sorghum stalks and thatched roof	Cobs with husks
M1	Muddied, emptied from top	Treated grain
M2	Muddied, emptied from top	Untreated grain
M3	Muddied, long term	Treated grain
M4	Muddied, emptied from bottom	Untreated grain
M5	Muddied, emptied from bottom	Treated grain

Figure 7 shows the simulation grain stores in the foreground and those containing cobs in the background. Owing to the initial delays in commencing field operations it was not possible to obtain information during the harvest period and the crop was already in store when the investigation began. By this time the selling period had also started and, taken together with a poor harvest due to drought, and the fact that farmers had selected their best maize for storage, this meant that the project had to make do with inferior quality maize for its simulation stores. Additionally, in respect of cobs it was learned, when the confidence of farmers had been obtained, that they carefully selected those which they put into store. However, by this time the simulation stores had been built and filled.

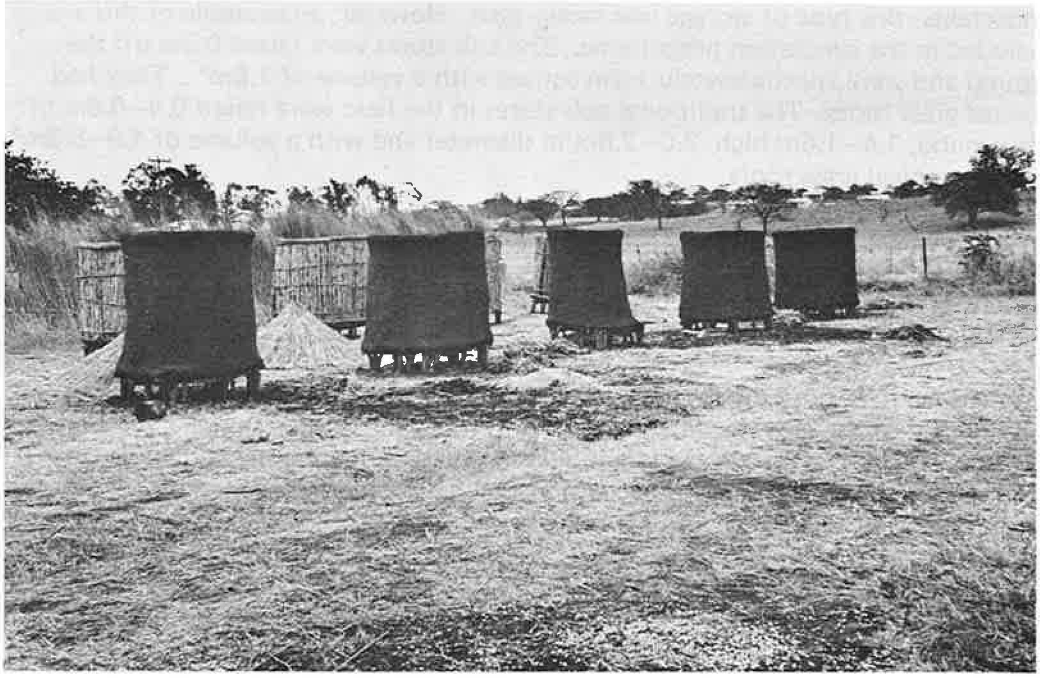


Figure 7 Simulation stores at Mt. Makulu — cob stores in background

SAMPLING PROCEDURE, ANALYSIS AND RESULTS

Procedure and analysis

Samples of 10 cobs, or 2 cups of grain, were removed both from the simulation and field stores as if for consumption. This sample gave 1.0—1.5 kg of grain. As sampling was continuous during the season, samples were taken at the time when the particular maize was reached in the normal process of consumption, so that on any one occasion samples did not need to be drawn from throughout the store. At the same time as samples were taken the store was examined for signs of rodent and termite damage. A note was made of grain removed since the last visit, its use and any changes to the number of people fed. Produce removed during sampling was replaced in kind. A benefit of adopting this practice is that when the grain received by the farmer is of better quality than his own it shows him that it can be kept in better condition. However, care was taken that the farmer did not mix this grain with that in his store.

The samples were analaysed in the following way. Husks were removed from cob samples and the percentage of cobs infested by insects and moulds or damaged by other means was noted. In the case of samples taken from farmers any cobs that he or his wife rejected as unfit for consumption were put in a separate plastic bag and fumigated with a little carbon tetrachloride; the reason for discarding and the possible use of the cobs being noted. The rest of the cobs were then shelled. The grain samples were also examined by the farmer or his wife and, as with cobs, any that was rejected was separately bagged and fumigated. The remainder of the sample was placed in another plastic bag but was not fumigated. All the samples were returned to the laboratory as soon as possible.

In the laboratory any rejected grain was weighed including that obtained from shelling the rejected cobs. The rest of the sample was weighed and then sieved with a sieve of the same aperture (6.35 mm in diameter) as that used by NAMBoard for grading the maize which they bought. The sample was then reweighed, the difference in weight giving a partial indication of the quality of the sample. The number of species of insects sieved off were noted, the commonest being *Sitotroga cerealella, Sitophilus zeamais* and *Tribolium castaneum*. The weight of a standard volume of the sample was then measured using the apparatus in Figure 8, according to the

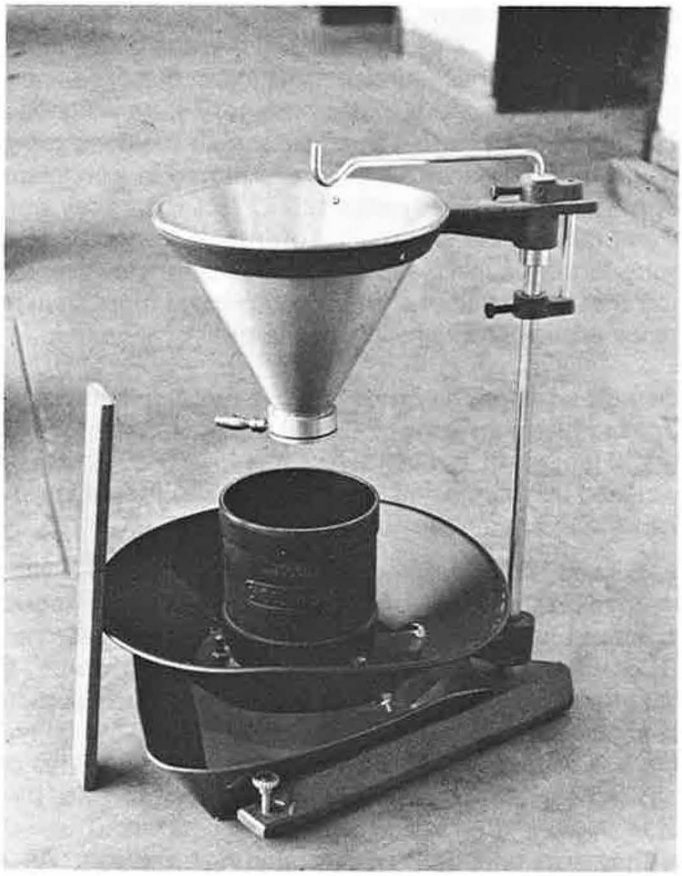


Figure 8 Bulk density measuring apparatus

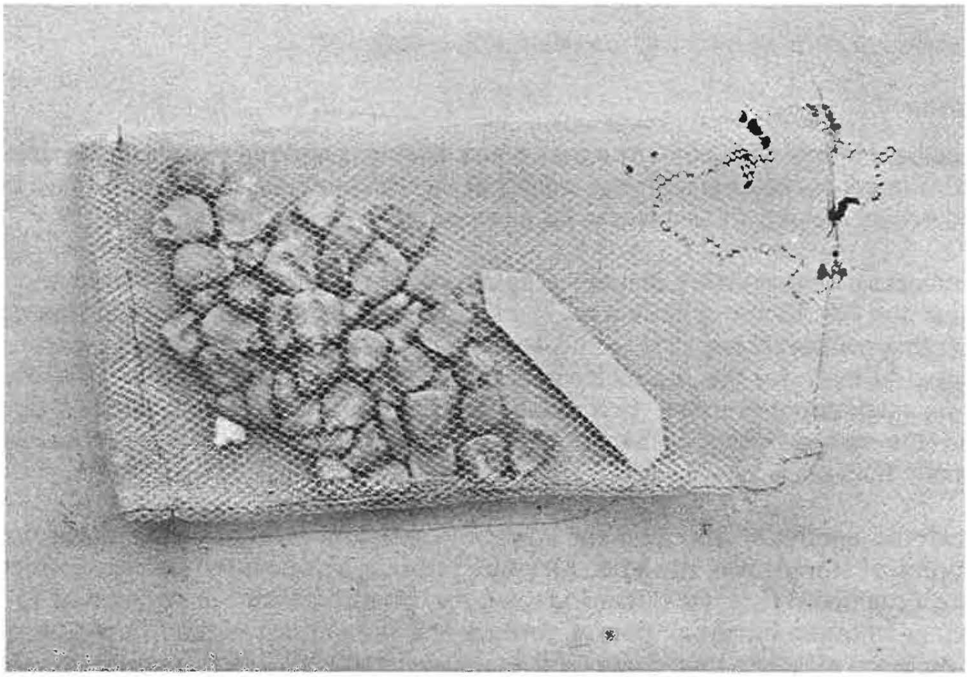


Figure 9 Small sample bag taken from store showing termite damage

method of Boerner (1916). For accuracy this was repeated three times. The moisture content was measured three times using a capacitance meter calibrated for the maize under test (CERA Tester calibrated against ventilated oven at 130°C for 1 hour).

The sample was then split into eight subsamples using a Boerner Divider and one was kept for detailed investigation. This was weighed and the grains counted: the grain was separated into four categories – undamaged, insect damaged, mould damaged and damaged by other means. The grains in each category were weighed and counted. The undamaged grains were put into a small jar and all the damaged grains placed in another jar. These were covered with muslin and placed in a constant temperature and humidity room (CTH) for three weeks (25°C 75% rh). They were sieved at weekly intervals and the number and species of insects recorded. It was not possible to keep the samples longer as space and time were short. However, from laboratory work it was found that the larvae of adults that emerged more than 3 weeks after sampling had caused negligible weight loss at the time of sampling.

In addition to the normal sampling procedure the simulation stores contained a number of control samples consisting of labelled cobs or small labelled bags made of mesh containing 100 g of grain through which the insects could pass freely (Figure 9). The cobs were weighed before placing in the store. The first layer of five cobs was put on the floor in the following positions:

1. North edge; 2. East edge; 3. South edge; 4. West edge; and 5. Centre. Two bags of cobs were then loaded on top, then another 5 cobs similarly arranged and so on until all 10 bags had been put in and there were 30 labelled cobs in each store. The labelled sample bags were arranged similarly in the muddied stores. In the case of stores M2 and M3 only 20 sample bags were put in; in the others there were 25. Treatments were allocated to stores at random M1, M3 and M5 being selected. After each bag of maize was poured in, 100 g of Blue Cross was sprinkled on top and stirred in with a stick before adding the next bag, as recommended by FCSU. Control bags were placed in position after the layer had been stirred. These control bags were removed as they were encountered throughout the season. As shown in Figure 9 a few suffered termite damage but were recovered intact. They were analysed in the same way as the normal samples.

Causes of loss

The various agents causing loss are dealt with below.

Moisture

An increase in moisture content masks a loss in weight and reduces the value obtained by consumers purchasing on a wet weight basis. Accordingly, calculations have been based on dry weight, so that losses are given in terms of dry matter.

An increase in the moisture content promotes the increase of storage insects and moulds and NAMBoard specify a maximum moisture content of 12.5% for the maize which they will purchase. Below this level it is unlikely that moulds will develop in storage. At maturity the Zambian maize crop has a moisture content of 30–35% and may be eaten as green maize. It is usually left to dry for a short time in the field before removal to the drying platforms in the village (Figure 1). The moisture content normally falls to 9–11% by June prior to sale.

In both the simulation and field cob stores the moisture content of the maize at the beginning of storage was 10–11%. Drying in store is aided by the free air circulation through the open store walls. During the rains this also permits absorption of moisture from the humid air passing through the store. Cobs without husks absorb slightly more moisture than those with the husks attached. Moisture contents of 15–16% were reached in all the cob stores (Diagrams 1 and 2) at the peak of the rains but fell to 13–14% by the end of the storage season. In this respect there was little difference between the traditional and Kimberley brick types of store in the field.

Air does not circulate freely through maize in the shelled grain stores and maize stored in these must be dry at the time of placing in store. The roof is often left off until the start of the rains but this probably has little drying effect. The moisture

Diagram 1
Mt Makulu: moisture content v time for cob stores

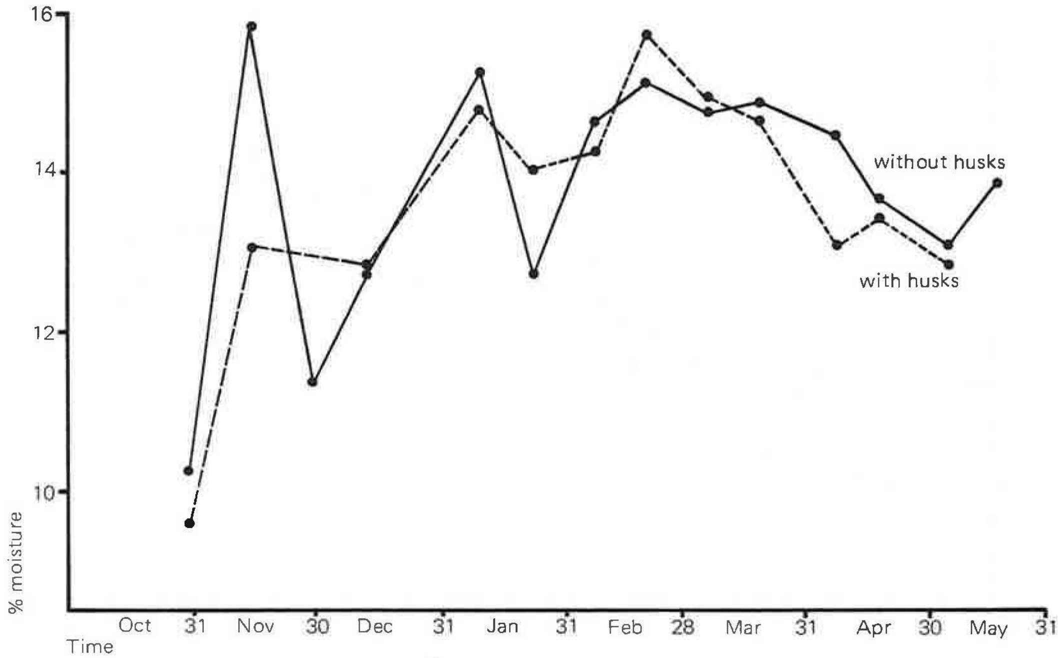
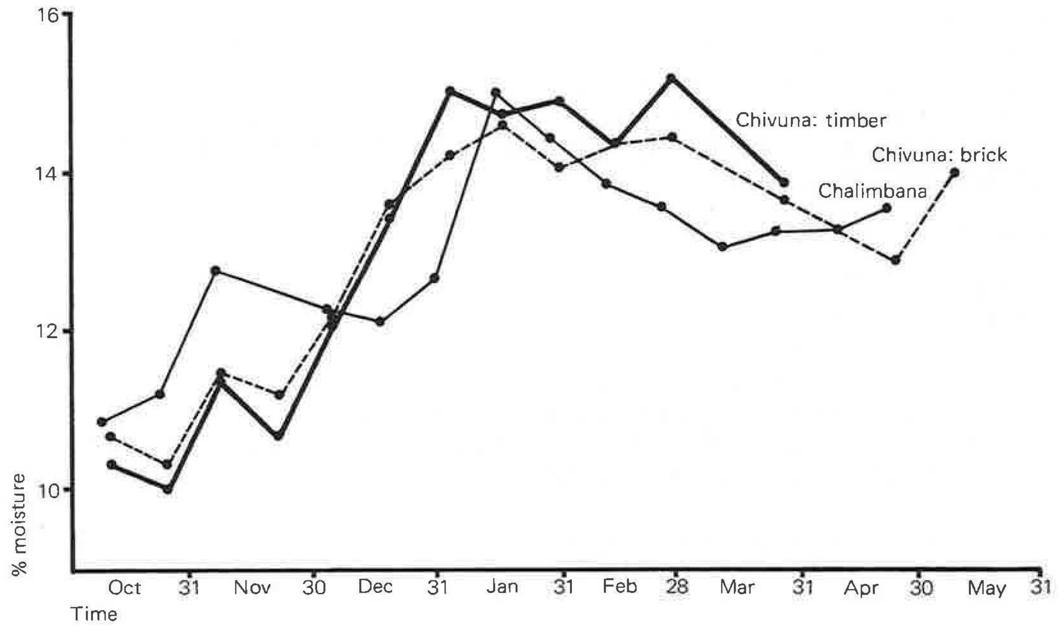
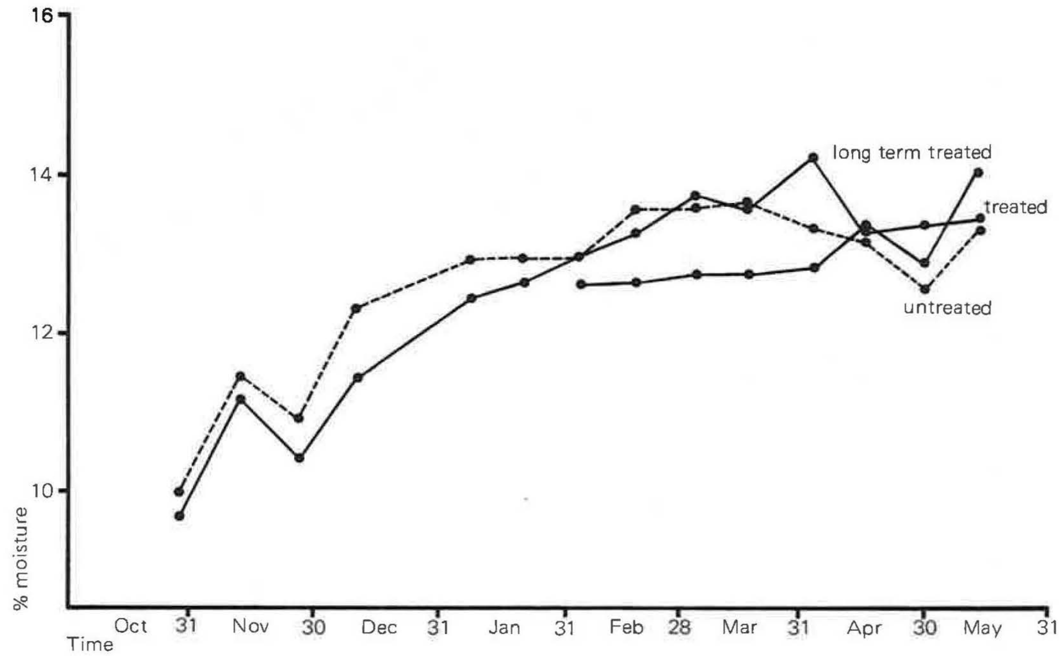


Diagram 2
Chalimbana and Chivuna: moisture content v time for field samples



content of shelled maize at the commencement of the investigation was 9–11%, in both the field and the simulation stores. The shelled grain is less exposed to humid air than cobs and the moisture content during the rains rose to 14–15%, the higher level being recorded in cases where the grain was taken from the top of the store. At the end of the storage period the moisture content was 13.5% (Diagrams 2 and 3). Breakdown of insecticides is likely to be lower in such stores because of the lower moisture content of the treated grain.

Diagram 3
Mt Makulu: moisture content v time for shelled grain stores



Mould

It is normally considered that storage of maize at a moisture content below that in equilibrium with air of a relative humidity of 70% is sufficient to prevent the growth of storage fungi. For the type of maize investigated this 'safe' moisture content is approximately 14% (Davey and Elcoate, 1965). As shown in the previous section none of the stored maize remained above this moisture content for very long and, apart from a few examples of mouldy grain from the bottom of some cob stores — up to 5% in some Chivuna samples at the end of the season — loss due to storage fungi was negligible in both simulation and field stores. A little discolouration due to infections by preharvest fungi was noted but, despite this, most of these grains were still consumed by the farmers.

Rodents

In view of the difficulty of estimating the extent of losses caused by rodents evidence of their activity in the stores was sought, such as droppings and grains with the germ bitten out. In addition, farmers were questionned about their rodent problems. Only one store, in Chivuna, had evidence of rodent attack and the farmer thought he could deal with the problem. Several farmers believed that Gamatox kept rodents away. However, the farmer with the rodent problem also used Gamatox. Muddied stores were considered by their owners to be fairly rodent proof.

Losses caused by rodents were unimportant in the stores investigated.

Termites

Termites are common in Zambia. They are virtually impossible to eradicate once within the store fabric. Farmers building timber stores usually construct at least the base, from resistant timber. A common repair is replacement of termite damaged timber. Occasionally, treatments of old engine oil or dieldrin are applied to the holes sunk for posts and to the posts themselves. Normally, little damage is expected to grain in store, but maize left to dry on the ground is frequently attacked. In the field stores investigated one old store was attacked. However, the cobs it contained were removed to a brick store before damage occurred. Two of the muddied simulation stores were badly damaged and, although only 5% weight loss occurred, approximately 15% of the grain was made inedible due to contamination.

Physical

Shelling damage was noticeable in machine shelled maize and averaged 11.2 broken grains per 100 g of maize. Traditional hand shelling appeared to cause negligible damage. Grains broken at shelling are more susceptible to attack in store by secondary pests* such as *Tribolium* spp. Some weathering discolouration was observed in cobs stored without husks but this would not constitute a loss.

Storage Insects

Virtually all the damage both to farmers' grain and to that in the simulation stores was caused by storage insects. The main primary pests* attacking undamaged maize in the field and in store were *Sitotroga cerealella* (Oliv.) (the grain moth) and *Sitophilus zeamais* Mots. (the maize weevil). One secondary pest, *Tribolium castaneum* (Herbst) (the flour beetle) commonly attacked damaged grains in store, a small population building up during the rains. There was a marked seasonal effect in the intensity of insect attack. *S. cerealella* was predominant until the end of February as it can develop better on dry grain, but after this period the rains increased the humidity causing the *S. zeamais* population to predominate.

Because cob maize packs loosely there is space throughout the store for *S. cerealella* to move and lay its eggs. In contrast, only the surface layer of a bulk of shelled grain is attacked because the moth cannot penetrate deeper. Thus, shelling alone is a potential method for partial control of *S. cerealella,* especially when maize is removed from the bottom of the bulk without exposing fresh grain to infestation.

The extent of the infestation was recorded by counting the number of insects sieved off the samples (Tables 18, 19 and 20) and by breeding out sub-samples in a CTH room over three weeks (Tables 21, 22, 23 and 24). In both cases samples from store 4 in Chalimbana (Table 23) had the highest infestation. Breeding appeared to decrease in the cobs without husks as damage approached 100%, probably due to competition for egg-laying sites and cannibalism between larvae. There was much variability between farmers' stores, some having very low infestations throughout the season. Fewer insects were recovered from the stores of farmers who had selected cobs for storage than from the untreated shelled grain and cob simulation stores.

Table 18

Mt. Makulu: live insects sieved from samples of cobs

Date	Live insects per kg			
	Without husks		*With husks*	
	C1	C2	C3	C4
30 Oct	8.5	0.7	0	17
14 Nov	1.8	4.0	0.8	8.5
29 Nov	0.7	1.6	4.2	0.5
13 Dec	0.7	4.2	0	7.7
10 Jan	1.4	6.0	3.1	10
23 Jan	2.4	2.4	7.2	3.9
7 Feb	1.4	1.6	3.8	5.6
20 Feb	4.8	5.1	12	16
7 Mar	20	11	4.4	7.2
20 Mar	50	11	26	21
8 Apr	34	24	7.0	0
18 Apr	42	13	47	47
7 May	5.3	12	33	49

*Primary pests attack undamaged grain, secondary pests grain already damaged.

Table 19

Mt. Makulu: live insects sieved from samples of shelled grain

Date	Live insects per kg				
	Untreated		*Treated*		
	M2*	M4	M1*	M3	M5
29 Oct	0	0.8	1	0	0
12 Nov	0.6	3.3	0	–	0
27 Nov	4.2	0.7	0	–	0
11 Dec	11	0	0	–	8.6
8 Jan	0.8	4.2	0	–	0
22 Jan	18	7.8	0	–	0
5 Feb	23	7.0	0	0	0
18 Feb	105	18	0	0	0
5 Mar	25	20	0	0	0
18 Mar	207	18	0	0	0
3 Apr	64	20	0	0	0
16 Apr	11	112	57	0	0
30 Apr	184	18	383	0	0
14 May	43	240	0	9.1	0

*These stores became badly infested by termites in the latter half of the period

Table 20

Chivuna and Chalimbana: live insects sieved from samples

Date	Live insects per kg			
	Chalimbana		*Chivuna*	
	Mean	Range	Mean	Range
9–11 Oct	2.7	0–6.3	7.5	0–23
23–25 Oct	1.7	0.8–2.6	2.0	0–8.0
6–8 Nov	6.5	0–12	5.5	0.5–21
22 Nov	–	–	5.0	0–20
4–6 Dec	8.1	–	4.2	0–15
18–20 Dec	16	–	4.2	0–25
31 Dec–4 Jan	13	–	5.5	0–26
15–17 Jan	285	–	6.5	1.4–18
29–31 Jan	31	–	18	0–50
12–14 Feb	262	–	19	1.4–30
26–28 Feb	253	–	19	0–93
12 Mar	314	–	–	–
26–28 Mar	311	–	17	0–45
9 Apr	329	–	–	–
22–25 Apr	299	–	20	0–41
9 May	–	–	24	22–25

– No observation

Table 21

Mt. Makulu: primary pests bred out from cob sub-samples over 3 weeks

Date	Insects per 100g			
	Without husks		*With husks*	
	C1	C2	C3	C4
30 Oct	59	21	4.4	3.0
14 Nov	31	32	0.6	7.3
29 Nov	61	48	2.7	2.0
13 Dec	41	101	8.0	4.9
10 Jan	11	17	5.4	14
23 Jan	12	9.0	17	19
7 Feb	5.1	2.6	16	22
20 Feb	7.2	1.6	13	16
7 Mar	11	13	23	9.3
20 Mar	20	13	23	22
8 Apr	24	23	9.7	11
18 Apr	16	16	18	21
7 May	20	11	24	14

Table 22

Mt. Makulu: primary pests bred out from grain sub-samples over 3 weeks

Date	Insects per 100g				
	Untreated		*Treated*		
	M2	M4	M1	M3	M5
29 Oct	0	0	0.7	0	0
12 Nov	3.7	3.3	0	–	0
27 Nov	15	5.7	0	–	0.6
11 Dec	4.7	7.5	0.6	–	0
8 Jan	21	22	0	–	0
22 Jan	12	6.9	0	–	1.3
5 Feb	12	6.7	1.1	0	0
18 Feb	8.0	0	0.7	0	7.3
5 Mar	30	17	1.8	0	0
18 Mar	26	21	2.3	0	0.5
3 Apr	33	30	10	0	0.6
16 Apr	45	20	11	4.3	4.4
30 Apr	46	6.6	60	8.4	2.0

– No observation

Table 23

Chalimbana: primary pests bred out from sub-samples over 3 weeks

Date	Insects per 100g				
	Store No				
	1	2	3	4	5
9 Oct	5.5	0	0.8	0	–
23 Oct	–	–	0	0	–
6 Nov	7.2	0.8	0	0	–
4 Dec	–	–	–	1.7	–
18 Dec	–	–	–	5.3	0
31 Dec	–	–	–	7.9	1.3
15 Jan	–	–	–	12	0.8
29 Jan	–	–	–	14	0
12 Feb	–	–	–	29	8.2
26 Feb	–	–	–	36	–
12 Mar	–	–	–	28	–
26 Mar	–	–	–	46	–
9 Apr	–	–	–	45	–
22 Apr	–	–	–	18	–

– No observation

Table 24

Chivuna: primary pests bred out from sub-samples over 3 weeks

Date	Mean No. Live insects per 100g	Range	No. of samples
11 Oct	0.9	0–2.8	8
25	0.5	0–1.8	13
8 Nov	1.0	0–2.8	13
22	1.2	0–4.5	13
6 Dec	1.7	0–10	13
20	3.3	0–12	13
4 Jan	3.2	0–9.6	13
17	4.7	0–12	9
31	9.1	0.4–23	12
14 Feb	8.5	0.8–21	12
28	14	0–30	11
28 Mar	19	0–52	11
25 Apr	18	2.2–34	6
9 May	17	6.0–30	3

However, treatment with Blue Cross drastically reduced the population, only a few insects remaining alive to breed at the bottom of the store beneath the emptying hole where they appear to have accumulated. This effect was important in the estimation of loss and is referred to later as the 'sump effect'. Damage caused by the two primary pests becomes visible on emergence of the adult insects, although by this time most of the loss caused by the insect has occurred. This visible damage was recorded as percentage damage. Grains were classified as either undamaged or damaged, regardless of the number of emergence holes, although those with more holes had obviously suffered higher losses. In all the samples damage increased with time (Diagrams 4 and 5). At the commencement of storage the cobs without husks exhibited over 30% damage which increased to 90–95% during the rains. During this period the damage per grain also increased. In the case of cobs with husks where damage was below 5% at the time of storage, selection by farmers restricted it to this low level until the middle of January. This was followed by a rise to 25% by the end of the season. There was no difference between SR52 and HK cobs.

Diagram 4
Mt Makulu: insect damage v time

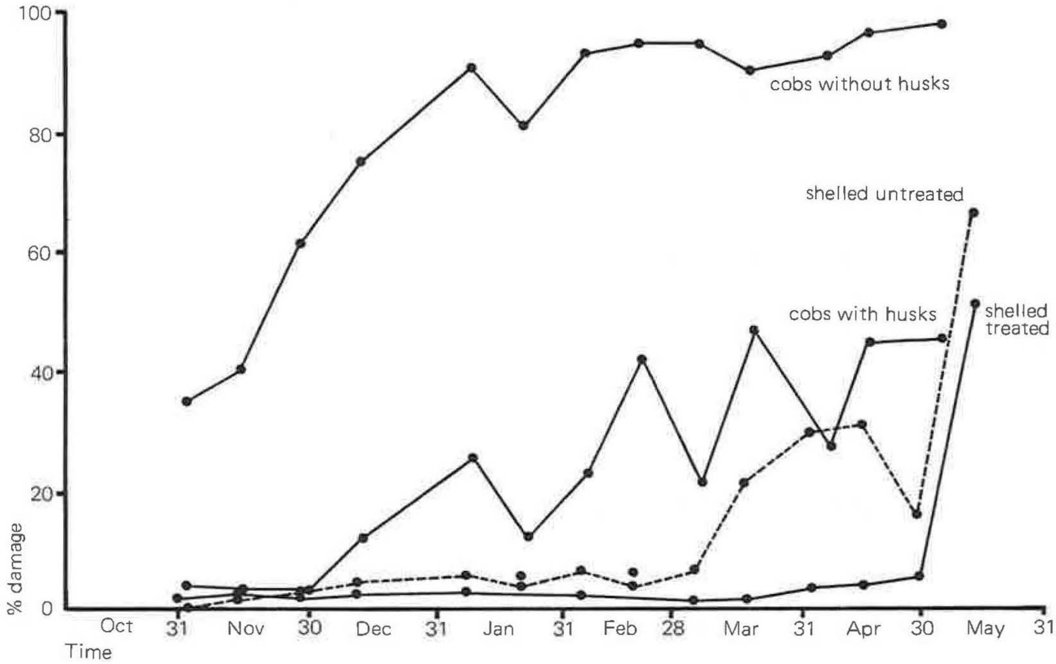
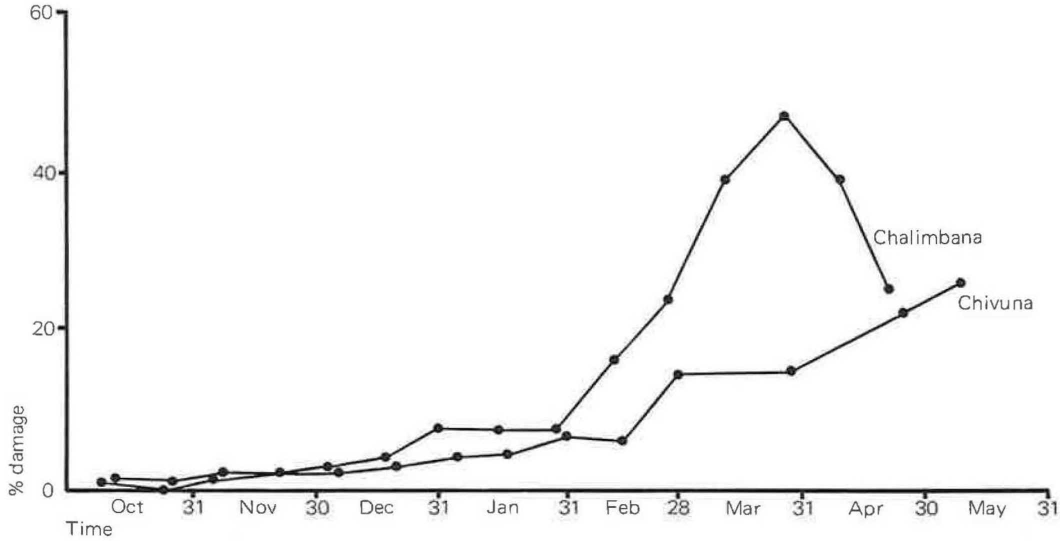


Diagram 5
Chalimbana and Chivuna: insect damage v time for field samples



Unselected cobs in the simulation stores suffered 45% damage by the end of the season but there was variation between cobs of differing husk cover. A similar level of damage was experienced in Store 4 in Chalimbana. In the simulation stores shelling, just by itself, kept damage below 5% until mid-March, after which there was a climb to 30% by the end of the season. Removal from the bottom instead of the top appeared to reduce damage even further. However the 'sump effect' resulted in 65% damaged grain at the bottom of the store on the final emptying.

Treatment with Blue Cross enabled the grain to be stored until the end of the season with less than 5% damage although the 'sump effect' still occurred in the bottom layer with 50% damage.

WEIGHT LOSS IN SIMULATION STORES

There were two measurements of loss for the simulation stores. One was obtained by weighing the grain entering and leaving the store. This gave a measure of the total or absolute loss which occurred over the storage period taken as a whole. The other, using control bags and labelled cobs, indicated the progress of loss with time.

Total weight loss

Table 25 shows the change in total weight and the change in the weight of dry matter for the shelled grain stores. The latter is important for the subsistence farmer who is using the stored grain for food but not so important if the grain is sold by weight, unless there is a limit on the moisture content acceptable to the buyer.

Table 25

Mt. Makulu: weight losses in shelled grain stores

Store Treatment	M1 +	M2 –	M3 +	M4 –	M5 +
Original wt put in store Kg	632.0	531.5	537.25	620.25	626.25
Original moisture content %	10.6	10.6	10.6	10.6	10.6
% wt change during storage	–3.8	–2.3	+2.8	–0.1	+1.4
Final moisture content %	16.7	10.7	14.0	13.3	13.4
% change in dry weight	–7.7	–5.4	+0.2	–2.6	–1.1

The highest total weight loss, even in the stores attacked by termites, was only 3.8% although this became 7.7% in terms of dry matter. Because of the termites the results from stores M1 and M2 are unreliable and the Blue Cross treatment of the maize in M1 did not have any noticeable effect on the total loss. However, it appears that losses in stores with grain removed from the top are greater than from those with removal from the bottom. For the latter stores there was virtually no loss in weight over the storage season, whilst in the two treated stores an increase in moisture content caused a weight gain.

In terms of dry matter the untreated stores (M4) lost 2.6%, the ordinary treated store (M5) lost 1.1% and the long term store (M3) lost no weight at all; the slight increase in the latter case is probably due to errors in converting to dry matter plus the addition of 600g Blue Cross after the initial weighing. The effectiveness of the Blue Cross treatment is clearly demonstrated in these results.

The cob store losses are more difficult to calculate in terms of dry matter because of the presence of other components — the husk and core — which suffer negligible damage compared with the grain. Moreover, their moisture relationships are unknown and were unmeasured because there is no standard method of determination. To calculate the losses it was assumed that both husk and core had a similar moisture content relationship to the grain. The dry weight of cobs put into store was calculated and also the sum of the dry weight of cobs removed on each sampling date. The difference between the two dry weights is the dry matter loss which, as the husk and core suffer negligible loss, may be taken as the dry matter lost by the grain during the storage period. To obtain the percentage dry matter loss one must compare this weight loss not with the total dry weight put in, but with the weight of shelled grain that it represents. To do this, prior to putting in store, 20 cobs chosen at random were weighed, dehusked and reweighed, and shelled and reweighed. The results of this indicated that shelled grain formed 82.5% of the weight of cobs with husks and 88.3% of the cobs without husks. The total dry weight was converted to dry weight of shelled grain using these percentages.

Table 26

Mt. Makulu: weight losses in cob stores

	Without husks		*With husks*	
	C1	C2	C3	C4
Original wt put in store kg	493.0	558.5	455.75	406.0
Original moisture content of grain %	9.7	9.7	9.7	9.7
% wt change during storage	–3.2	–3.5	–6.8	–6.6
Final moisture content of grain %	13.6	13.9	12.8	12.8
% change in total dry matter of cobs	–7.6	–8.0	–10.9	–10.7
% change in grain dry matter only	–8.6	–9.1	–13.0	–13.0

The percentage of dry matter loss for cobs with husks (Table 26) was 13.0% for each store and for cobs without husks 8.6% and 9.1%. These losses refer only to the period of investigation. The lower weight losses for cobs without husks is not a true reflection of their loss over a full storage season since they had already suffered a considerable loss before storage. Their overall weight loss was probably in the region of 15–20% if this is taken into account.

Weight loss in control samples

It was hoped that the presence of the mesh enclosing the small sample bags would have little effect on the movement of insects, enabling loss in the bags to be compared with that in the bulk. Unfortunately, the mesh did appear to influence the results, as variables in the control bags were not closely correlated with the same variables in the bulk samples. The percentage damaged grain figures indicate a possible restriction because they are higher and more variable in the bags over the first four months. All the losses given are in terms of dry matter.

In the stores attacked by termites (M1, M2) only 55% of the control bags were recovered intact, only one bag being recovered later than February. Although these results cannot be included in the general analysis because of the termites, weight losses were below 1% for all the bags recovered.

In the long term treated store (M3) the treatment was so effective that no weight losses were found until the bottom layer of bags was removed during April. These showed a mean loss of only 5.1% possibly due to the 'sump effect' mentioned before, as it was not reflected in the total loss figure.

In the other treated store (M5) the effect of the treatment was similar with only the bottom layer suffering a mean loss of 18.4% (range 14.5—22.5%), yet in two bags from the layer above, removed on the same date, losses were below 0.4%. This effect is obviously caused by position rather than time. Very little of the maize was heavily attacked so that the losses in the bottom layer represent only a small fraction of the total.

The remaining store (M4) was untreated and was the only one suffering losses in weight of sample bags in more layers than the bottom. Because of this the analysis has been concentrated upon it. Again there was an obvious 'sump effect' with a mean loss over the five bags of 29.1% (range 18.9—39.4%) occurring in the bottom layer. Negligible losses were recorded up to the beginning of January, but rose to 1.5% in February, 2.5% in March and to 3.4% by the end of April. These clearly demonstrate the seasonal nature of loss and its cumulative effect which, if produce had to be kept over until the next season could become important. Shelling alone, even without treatment, appears to reduce losses compared with similar grain stored on the cob. The 'sump effect' demonstrates how easy it is to obtain an exceptionally high estimate of weight loss by sampling at the end of the season when only 10% or less of the grain may be left in store.

Analysis of the bag samples was done using multiple regression. It is mentioned at this point because it was not suitable for comparison with the bulk. The 'sump effect' complicated the analysis and was done separately. Certain variables were not significantly correlated with dry weight loss such as live insects per kg, insects bred out per kg and results from the use of a formula (discussed later under gravimetric methods). Significant correlations were % dust ($r = 0.8148$), dry weight of 100 grains ($r = -0.5070$), % damaged grains ($r = 0.8389$) and number of days in store ($r = 0.7373$). The resulting equations and standard errors are given in Table 27.

Losses were six times higher than expected for bags in the bottom layer with high standard errors. As % damaged grain reached 100% it was no longer a reliable estimator. However an equation including the bottom layer, represented by a dummy variable (x_3) was proposed ($x_3 = 0$ except when the bottom layer is considered, then $x_3 = 1$).

$$Yc = -1.159 + 0.0078x + 0.121\, x_2 + 10.43\, x_3$$

Standard error of estimate 1.25

where Yc — % weight loss
x_1 — days in store
x_2 — % damaged grain
x_3 — position in store.

Table 27

Mt. Makulu: control bags, store M4. Results of regression analysis

Estimator	Regression Equation (Yc = % weight loss)	Standard Error of the estimate
% dust x_1	$Yc = 0.024 + 5.905\, x_1$	1.130
By wt of 100 grains x_2	$Yc = 2.935 - 0.1105\, x_2$	1.680
% damage x_3	$Yc = 0.626 + 0.1437\, x_3$	1.061
Number of days in store x_4	$Yc = 1.368 + 0.0237\, x_4$	1.317
Most efficient pair x_1 x_3	$Yc = 0.589 + 3.260\, x_1 + 0.090\, x_3$	0.914
Most efficient three x_1 x_3 x_4	$Yc = 1.140 + 3.223\, x_1 + 0.0567\, x_3 + 0.0093\, x_4$	0.840

The results from the labelled cobs are more difficult to interpret because of the husk and core. For the cobs stored without husks (Stores C1 and C2) the recovery rate was 87%. Wet weight losses as a percentage of the total cob were extremely variable ranging from gains of around 5% to losses of 10%. With alomst identical mean losses the two stores were comparable and to convert the losses to dry weight it was assumed that the change in the moisture content of the core paralled that in the grain. It is likely that the error involved in doing this is fairly small as a core forms only around 10–15% of the cob weight. Applying this correction gives dry weight losses ranging from less than 1% in November up to 15% in April/May. These losses were still variable and the high level of damage with which the cobs went into store obviously had an influence on the subsequent loss. The same variables were tested for correlation with % dry weight loss as in the grain stores but only numbers of days in store x_1 (r = 0.824) and % damaged grain x_2 (= 0.677) were found to be significant. As the mean % damaged grain was 85% with only four observations below 50% the importance of it is probably underestimated in the following equation:

$$\% \text{ wt loss } Yc = -1.14 + 0.0454\, x_1 + 0.0379\, x_2$$

Standard error of estimate 2.46

x_1 — days in store

x_2 — % damaged grains

Using this and the almost linear loss in dry weight over the period under investigation one obtains an estimated daily loss of 0.054%. If this figure is applied to both stores and the sum of the original weight of all removals calculated, the result is within 0.5% of the quantity weighed into the store. This demonstrates the greater significance of time in store in relation to loss compared with damaged grains. This loss refers to the whole cob. If a % loss in grain weight is required, an approximate correction can be applied by multiplying by 1.15.

One would not normally find cobs stored in this manner in the area studied in Chivuna. Instead they would be stored with the husks intact, and would incur less damage.

Investigation of the labelled cobs with husks in stores C3 and C4 showed that the dry weight losses in each stores, were comparable but that these were generally lower than for the cobs stored without husks in stores C1 and C2. Apparent weight gains may be due to errors in relating moisture contents of the husk to grain moisture content. Most of the losses were between 2 and 4% but during April/May they rose to approximately 5%. There was however considerably differing levels of infestation present at the time of storage. Because the damage was lower than for cobs without husks with little multiple infestation it provided a more reliable estimate in the equation:

$$\% \text{ weight loss } Yc = 1.74 + 0.0106\, x_1 + 0.0708\, x_2$$

Standard error of estimate 1.64

Again number of days in store x_1 (r = 0.768) and % damaged grains x_2 (r = 0.912) were the only variables significantly correlated with % dry weight loss. Use of an estimated daily loss is unreliable in this case due to the overriding importance of damage. To obtain the % weight loss of the grain rather than the whole cob a correction factor of approximately x 1.20 should be applied.

In cobs with husks a 1% loss in grain weight is approximately equivalent to 8.3% damage.

Analysis of the results from the cob stores shows the considerable problem in assessing their losses due to the presence of the husk and cob core. Apart from errors inherent in converting the moisture contents one must estimate the quantity of grain in store to which the loss must be applied. In practice it is probably best to obtain a large sample at the time of storage and calculate a shelling out percentage to apply to the crop as it goes into store. Because this percentage will change during the season all subsequent removals and loss estimates need to be done using shelled grain weights only.

ESTIMATION OF LOSSES

Weight loss

Techniques of assessment

Part 2 briefly introduced the various techniques that have been employed in the estimation of weight loss from samples of grain. Several of these were tested for their practicality and for their accuracy in estimating loss. Relationships between easily measured variables and weight loss were also investigated for application in the field. Because of the very low losses encountered in the shelled grain stores and the termite problem, only one untreated store (M4) could be used for analysis. All the cob stores were used as their losses were considerably higher.

The techniques for loss assessment are grouped into volumetric, gravimetric and indirect.

Volumetric. A standardised piece of apparatus (Figure 8) was employed to obtain a fixed volume of grain, one quart (1,220 cc). The sieved sample was allowed to run into the standard container from the cone above and the surface was smoothed off using three zigzag strokes as described by Boerner (1916). The container of grain was then weighed. This was repeated three times and the mean taken.

The change in the weight of the given volume of grain at different times was taken to reflect the loss caused by insect damage. It should be noted that this would not be a safe assumption in cases where excessive damage occurred sufficient to cause loss in shape and to affect the overall volume occupied by the grain. This did not happen in the project and it is considered therefore that measuring the weight of a volume throughout the storage period and comparing it with the original weight gave a realistic estimate of weight loss with time. Moisture content changes affecting the weight can be excluded by conversion to dry matter. However it was found that moisture content changes also affected the volume and frictional properties of the grain. An increase in moisture content was found to increase the grain volume and cause it to pack more loosely leading to a decrease in the weight of a given volume. Browne (1962) and Hall (1972) both discuss this effect, and Mangels (1927) deals with other variables affecting bulk density.

The relationship between moisture content and weight for the volume used was investigated. Several kilos of grain were hand sorted to remove visibly damaged kernels. The remainder were placed in large jars sealed with muslin and placed in the CTH room. These were sieved daily over a period of twelve weeks to remove insects and prevent breeding. At the end of this period no insects had emerged for several days and all the visibly damaged grains were removed. This left a completely undamaged reference sample without any internal infestation. Samples of this grain with different moisture contents ranging over those expected in the field were obtained, either by drying a thin layer in a ventilated oven at 40°C to prevent any case hardening until the required moisture content was reached, or by adding a calculated quantity of water to grain in a sealed jar and shaking thoroughly daily for three weeks. Jamieson (1970) gives the formula for the amount of water required for a given moisture content. All samples for these treatments were chosen at random using a Boerner divider, and moisture contents were measured using replicated ground samples in a ventilaged oven for one hour at 130°C.

These samples were used to determine weight per unit volume and for calibration of the moisture meter employed in analysis of the field samples. The weight of maize in the container when plotted against the percentage moisture content resulted in a curve. Plotting the weight of dry matter against percentage moisture content resulted in a linear relationship. Regression analysis proved that this was an excellent fit and could be used to predict the dry weight of the standard volume of maize at any moisture content within the range. The difference between this and the dry weight of a volume of damaged maize gives an accurate measure of the weight loss. This is variety dependent and was done for both SR52 and the HK type of maize. However, it was found that the addition of insecticidal dust had a noticeable effect on the weight even after sieving. The dust sticks to the grains causing an increase in their volume and a change in their frictional properties, which in calculation represented an apparent loss in weight of 7.2%. Testing with lower rates gave apparent losses of 5.4% at quarter dosage, 6.2% at half and 7.1% at three-quarters. Treatment at higher than recommended dosages had the same effect as treatment at the recommended rate after the excess loose dust was removed by sieving. These figures were obtained from three replicates all at 13.4% moisture with very close agreement between replicates. The results meant that the use of unit volume in cases where insecticide had been applied to shelled grain was less useful, because one could not be sure of the effect of dust remaining on the grain. As mentioned previously, dusting of cobs would have negligible effect on the resultant shelled grain since the dust rarely penetrates through the husk.

The following regression equations were calculated for use in the prediction of the weight of dry matter in a quart of undamaged grain, for use with untreated shelled maize, for untreated cobs minus the sheath, and for all cobs with the sheath intact.

For SR52 $y = 851.8 - 12.84x$ Standard error of estimate 2.67

For HK type $y = 887.4 - 15.05x$ Standard error of estimate 3.79

y — weight of dry matter in 1 quart

x — moisture content

The effect of varietal differences is obvious in these equations. HK type is a composite of local types and the Hickory King variety, so that prediciton is less accurate.

Damage due to mechanical shelling probably affected the weight per unit volume as well but would not have been important in the cob maize that was shelled carefully by hand.

The information about the behaviour of a constant volume of grain made it possible to obtain weight losses, using the difference between the original weight of a standard volume at a standard moisture content and the weight of the same volume converted to the same moisture content during the period of observation. Therefore using a volumetric method alone and starting at the time of storage with knowledge of the volume/moisture content relationship, a good estimate of loss can be obtained once an allowance has been made for the relevant factors. A modification of this method is suggested following a review of the other techniques of assessment.

Gravimetric. Two main methods were used in this category. The first was the weight of 100 grains; the effect of moisture being removed by using the dry weight. The relationship of this to percentage weight loss in the bag samples was:

$Yc = 2.94 - 0.111x$

Standard error of estimate 1.68

Yc — percentage weight loss

x — the dry weight of 100 grains

correlation coefficient (r) = −0.507

For the bulk samples the correlation was not significant.

This was not a particularly good estimator of weight loss compared with other methods probably due to the variability of maize grains. Those at the tip, may be a third of the size of those near the base. In more uniform grains comparison of 100 grain weight with an undamaged standard throughout the storage season may be of more use with the proviso that the selection of grains is unbiased. The other gravimetric method tested is that used in francophone Africa and devised by the Commission for the Evaluation of Losses (Anon. 1969). In this method, instead of comparing the weight of grains in a sample with a standard over a period of time, a comparison is made between damaged and undamaged grains in the sample. This is to allow an estimate to be calculated based on a single sample only, taken at any time. Naturally the result would only apply to that particular sampling occasion.

The equation used is:

$$\% \text{ weight loss} = \frac{(UN_d) - (DN_u)}{U(N_d + N_u)} 100$$

U — weight of undamaged fraction of sample

D — weight of damaged fraction of sample

N_d — number of damaged grains

N_u — number of undamaged grains

This formula was used to estimate losses in both control and bulk samples. It was found that the results were not significantly correlated with the observed weight losses. The discrepancies were mainly at low and high levels of loss, the intermediate range giving an approximate estimate. The reason for this may be that at low loss levels invisible internal infestation may occur and grains with this would be counted as undamaged, therefore underestimating the loss. If the above equation is put into the simplified form:

$$\% \text{ weight loss} = \% \text{ damage} \quad (1 - \frac{\text{mean weight of damaged grains}}{\text{mean weight of undamaged grains}})$$

it can be seen that the estimate will only be valid if the damaged and undamaged sub-samples are closely comparable in original size of grains. If, for instance, the insects prefer the larger grains, the mean weight of damaged grains could exceed that of undamaged grains, resulting in a negative estimate of loss. Such estimates frequently occur using this formula. At high infestation levels the problem of multiple infestation obscures the issue as the weights of damaged grains will be very variable.

These considerations meant that this method for estimation of losses could not be used in this project. However, it may be of use in single visit surveys especially with smaller grains of more uniform size which are not liable to multiple infestation, such as wheat, rice, sorghum; and for infestations without internal feeding stages.

Indirect. This approach utilises various factors which are related to loss from which an estimate of its amount may be made. The most suitable method of investigating these relationships is regression analysis. Brief reference has already been made to those variables which were found not to be correlated with observed loss. These included:

1. Number of live insects sieved off samples. Problems include the mobility of insects which move away after causing damage, movement when the sample is taken, difficulty of extracting adults from holes in grains on sieving. All these lead to great variability and practical difficulty.
2. Number of insects bred out. This will relate to the loss at the time of emergence rather than at the time of sampling and as such would give an indication of potential loss. It is difficult to use in practice as a controlled environment is needed to keep the samples, and insects may have to be sieved off at daily intervals to prevent further breeding.
3. 100 grain weight. This is of more use directly, as a continuous measure against a standard taken at the time of storage.

Of those estimators that were significantly correlated with observed loss percentage dust was found to be useful in the control samples except at the bottom of the store, but not significant in the bulk samples. In a limited space such as a jar, dust is an excellent estimator of loss but in the field situation it is too mobile tending to filter through shelled grain and be lost during sampling. Because of this, it has not been used to estimate the losses in the stores investigated.

This leaves the percentage damaged grains, probably the commonest estimator in use for loss estimation. This had the best correlation ($r = 0.966$) with observed loss with the lowest standard error for estimation. However, it ceases to be an efficient indicator as 100% damage is reached and may be suspect because of multiple infestation in large grains such as maize. In the shelled grain store M4, 1% damage was found to be associated with a 0.12% weight loss, so that multiplying percentage damaged grains by $^1/_8$ th would have given an approximate percentage estimate.

For the cobs removed from the simulation stores, percentage damage had the best correlation with weight loss. It was found that the addition of time in store to the equation helped to allow for the non-linear nature of percentage damage. In many cases this makes little practical difference to the estimate over a storage period of 6 — 9 months for example, for the shelled grain store at Mt. Makulu.

% weight loss $Y_c = -1.16 + 0.0078 + 0.121\ x_2$

Standard error of estimate 1.25

x_1 — days in store

x_2 — percentage damaged grain

It would therefore take 128 days for time in store to contribute 1% loss to the estimate.

One of the problems with the use of percentage damage in relationships to determine weight losses is that insects are more likely to consume a fixed quantity of grain rather than a percentage of grain. In a laboratory experiment using *Sitophilus zeamais* and fifty single maize grains, no correlation was found between weight loss and grain size ($r = 0.083$), but the weight consumed per insect was constant with a mean of 27 mg. However, there was a significant difference ($P < 0.001$) in quantity consumed by a solitary insect (35.1 ± 4.3 mg) and the quantity consumed per insect in cases of multiple infestation (25.8 ± 0.9 mg).

There was no difference in the weight of weevils from single or multiple infestations which was 3.1 ± 0.1 mg. This relationship has also been observed by Gerberg and Goldheim (1957) and Jotwani and Sircar (1964) and is important in maize. It would probably not apply in smaller grains with negligible multiple infestation by species developing within the grains.

Estimates

This section combines the information from the previous paragraphs to obtain a method of assessing losses under the conditions experienced by the project and gives the resulting estimates. In using these the disadvantages of the various methods of estimation must be borne in mind. However, by using a combination of them the best estimates possible from the data are obtained.

The use of several variables in the regression equation, although useful in this study in giving an indication of the relative importance of each, is not suitable for a general loss survey.

The comparison of constant volumes of grain, when corrected for moisture content, gave excellent results for losses within 1% of the observed values.

Using this in combination with percentage damage and time in store estimates were obtained for the various stores.

1. Simulation stores

Of the shelled grain stores only store M4 suffered a measurable loss suitable for comparison with estimates. A regression equation relating time in store and percentage damage grains gave the best estimate of loss.

$Y_c = -1.16 + 0.0078x_1 + 0.121x_2$

Standard error of estimate 1.25

Y_c — % weight loss

x_1 — days in store

x_2 — % damaged grains

The resultant losses are shown in Table 28.

Table 28

Mt. Makulu: regression estimates of dry weight loss

Week ending	% Weight loss				
	M4	C1	C2	C3	C4
2 November	0	0.76	0.76	1.07	1.55
16 November	0	1.57	1.57	0.75	1.90
30 November	0	2.38	2.38	1.85	1.26
14 December	0	3.13	3.13	5.66	1.97
11 January	0.21	4.64	4.64	7.82	6.98
25 January	0.04	5.35	5.35	7.68	4.32
8 February	0.49	6.16	6.16	7.01	7.74
22 February	0.27	6.86	6.86	11.71	11.93
8 March	0.71	7.67	7.67	5.70	9.38
22 March	2.55	8.37	8.37	14.38	12.73
5 April	3.70	9.40	9.40	6.15	13.19
19 April	3.94	9.94	9.94	16.62	10.84
10 May	2.28	10.96	10.96	18.00	10.62
17 May	8.48	11.56	11.56	–	–
Mean	1.62	6.34	6.34	8.03	7.26
Consumption Corrected	2.5	8.6	8.5	12.0	10.6
Observed	2.6	8.6	9.1	13.0	13.0

The consumption corrected figure is obtained by converting the quantity removed to its expected weight if no loss had occurred and comparing the total observed weight removed with the total expected weight removed. The estimate of 2.5% is very close to the observed loss of 2.6%.

A similar calculation was done for the cobs without husks as they behave in a similar way to shelled grain, all the grains being equally accessible to infestation. The regression equation for stores C1 and C2 is:

$$Yc = -1.14 + 0.0454x_1 + 0.0379x_2$$

Standard error of estimate 2.46

Because the time in store is important a rough estimate of daily loss of 0.054% could be used. The loss occurring before storage was high, probably at least 5%, but it has not been included in Table 28. The estimated losses during storage of 8.6% for C1 and 8.5% for C2 are again close to the observed losses of 8.6% and 9.1% respectively.

Cobs with husks behave differently as the husks tend to localise the infestation so that the damage variable assumes greater significance. Several variables were used in multiple regression analysis to obtain a better estimate. The data for cobs stored in the Chivuna area were also used to provide more information. A regression of the type $Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3$ was fitted.

For SR52 this equation was

$$Y = 799 - 0.171x_1 - 1.77x_2 - 0.107x_3$$

Y – observed weight of a standard volume.

x_1 – number of days in store counting the first observations date as zero.

x_2 – percentage damaged grain.

x_3 – percentage moisture.

Elimination of x_1 and x_2 shows that a constant volume of grain weighs less as the moisture content increases. After fitting by linear regression it may be assumed that

b_3 is constant in the observed range of values for x_3 (10 – 16%) and therefore Y can be corrected to a standard value of moisture. This value was taken as 10% because this was the approximate value at the time of storage. The difference between each observed value of Y and the original value at the time of storage gives a good estimate of the loss. This estimate can be smoothed by use of the regression equation to reduce variation between estimates in the same set. The resulting equation is:

$$Y_c = 0.0214x_1 + 0.222x_2$$

Y_c – percentage weight loss

x_1 – number of days in store

x_2 – percentage damaged grains

In simplified terms the percentage dry weight loss could be expressed as 2/9 of the percentage damaged grain plus 0.15% for each week in store.

The results in Table 28 compare favourably with those obtained by weighing, although both are subject to errors in the conversion of cob weights to shelled grain weights.

2. Chivuna

The regression estimates of dry weight losses are shown in Tables 29 and 30. These results were obtained by the same method as those for cobs with husks at Mt. Makulu. There was a distinct difference between the behaviour of the SR52 and HK type maize and an equation for each has been calculated.

For SR52 $Y_c = 0.0214x_1 + 0.222x_2$

For HK type $Y_c = 0.0197x_1 + 0.163x_2$

Y_c percentage weight loss

x_1 number of days in store

x_2 percentage damaged grains

HK type maize is apparently less susceptible to infestation than SR52 and losses were approximately 1/6th of the percentage damaged grain plus 0.14% per week in store compared with 2/9th and 0.15% for SR52.

Table 29

Chivuna: regression estimates of dry weight loss through time by type/variety of maize

Date	% Weight loss	
	Mean SR52	Mean HK Type
11 October	0.09	–0.08
25 October	0.22	0.28
8 November	0.81	0.82
22 November	0.79	1.31
6 December	1.62	1.18
20 December	2.13	1.64
4 January	2.63	2.10
17 January	2.78	2.55
31 January	3.90	3.38
14 February	3.79	3.36
28 February	6.27	4.84
25 March	7.52	4.91
25 April	8.34	7.62
9 May	10.00	8.22
Mean	2.84	2.64

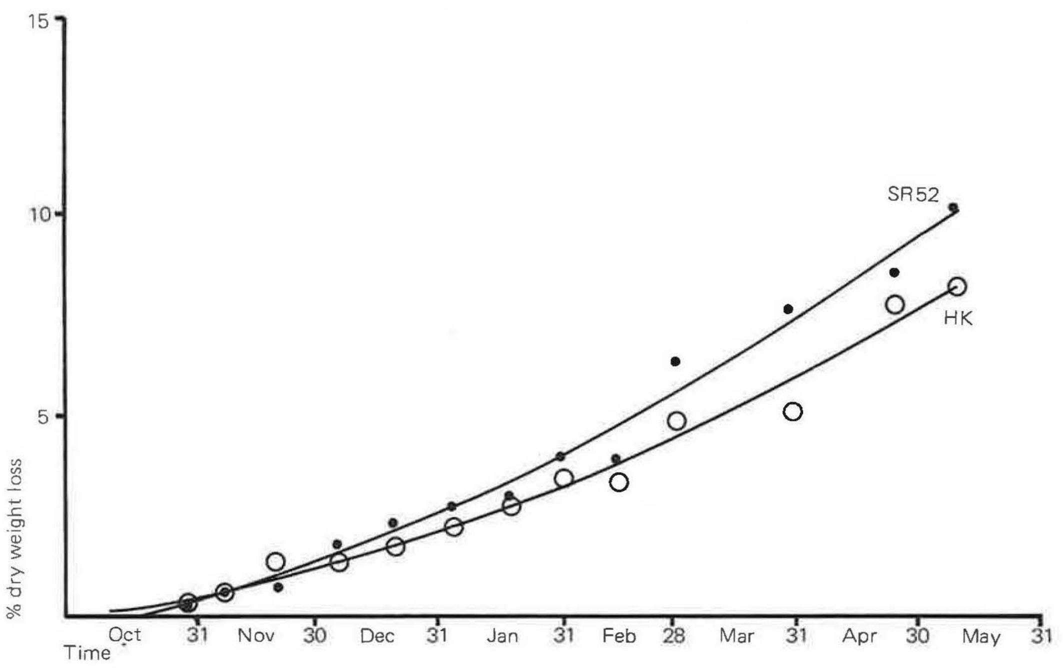
Table 30

Chivuna: regression estimates of % dry weight loss through time in individual stores

Date	SR52							HK Type					
	1	2	5	6	7	8	9	3	4	10	11	12	13
11 October	0.06	−0.19	−0.19	−0.13	0.72	0.28	–	−0.05	−0.11	–	–	–	–
25 October	0.13	0.41	0.12	0.12	0.41	0.18	0.20	0.28	0.22	0.12	0.26	0.35	0.48
8 November	0.92	0.63	1.06	0.43	1.14	0.91	0.59	1.05	0.69	1.02	0.39	1.25	0.53
22 November	0.73	0.99	0.73	0.91	0.73	0.73	0.73	0.82	0.81	1.39	1.65	2.21	0.99
6 December	1.95	1.70	1.03	1.51	2.75	1.17	2.23	1.22	1.21	1.20	0.95	1.20	1.29
20 December	1.63	1.95	3.95	2.44	1.44	1.49	2.04	1.48	1.39	1.55	1.73	2.25	1.45
4 January	2.99	2.68	3.84	2.13	2.44	1.65	2.70	2.33	1.52	1.94	1.91	3.37	1.52
17 January	3.31	2.65	–	–	–	–	2.39	3.20	1.77	2.69	2.93	2.59	2.10
31 January	–	2.90	2.92	4.37	6.16	4.79	2.23	3.28	2.17	2.47	5.64	4.66	2.05
14 February	–	3.58	3.89	3.85	3.70	3.56	4.17	2.97	2.32	4.41	3.46	3.96	3.03
28 February	–	4.64	6.39	8.37	6.50	6.31	5.39	4.87	2.77	6.65	–	6.84	3.08
25 March	–	10.19	10.68	6.23	6.20	7.62	4.17	7.53	3.55	5.91	–	3.70	3.86
25 April	–	–	–	–	6.41	–	10.27	–	4.07	11.38	–	7.65	7.37
9 May	–	–	–	–	–	–	10.00	–	5.23	11.21	–	–	–
Mean	1.46	2.68	3.13	2.75	3.22	2.61	3.62	2.42	1.97	4.00	2.10	3.34	2.31

– No observation

Diagram 6
Chivuna: estimate of percentage dry weight loss v time



The results of the calculations in Table 29 were used to obtain the regression lines shown in Diagram 6. The best fit was obtained using a quadratic function which accounted for 98.2% of the variation in the SR52 results and 98.3% of the variation in HK results. The resulting equations for percentage by loss weight (Y_c) in terms of weeks in store (x) were:

for SR52 $Y_c = 0.0551 + 0.146x + 0.0062x^2$
Standard of error of estimate 0.046

for HK $Y_c = 0.185 + 0.0920x + 0.0058x^2$
Standard error of estimate 0.036

All the regression coefficients were significantly different from zero at the 5% level. The differences between the regression coefficients for the two types of maize were not significant because their 95% confidence limits overlapped. However, the two curves do diverge and there could be important differences beyond the observed period of storage.

The advantage of selecting cobs for storage is demonstrated by the much lower estimated losses for the farmers' stores compared with those at Mt. Makulu for which there was no selection. To calculate the losses in individual stores the consumption data collected on each sampling occasion were utilised (Part 5). This was given in terms of tins of shelled grain consumed since the previous visit. A tin of 4 gallon capacity is commonly used as a measure in rural areas and 6 tins were said to be equivalent to a 90 kg bag of maize. One tin is equivalent to 15 kg. Using the approximation that the volume of undamaged grain in a tin would be the same as that of damaged grain, the number of tins a farmer removed from his store were converted to weight. This was taken as the quantity he intended to remove. However, some of this maize had been lost. To obtain a measure of this amount the estimated percentage loss was applied to the consumption data, thus arriving at the weight he actually removed. The difference between what was actually removed from a store and what was intended gave an estimate of loss based on consumption (Table 31).

Table 31

Chivuna: total dry weight losses in individual stores*

Store†	Variety	Wt of removals with no loss. Kg	Loss in weight. Kg	% Loss in weight
1	SR52	480	8.2	1.7
2	SR52	630	34.6	3.8
3[a]	HK	375	15.0	4.0
4[a]	HK	880	23.2	2.6
5[b]	SR52	1,440	92.4	6.4
6[b]	SR52	1,365	79.9	5.9
7[b]	SR52	1,320	64.3	4.9
8[b]	SR52	880	47.3	5.4
9	SR52	805	40.0	5.0
10[c]	HK	740	30.9	4.2
11[c]	HK	495	10.2	2.1
12[d]	HK	405	17.9	4.4
13[d]	HK	465	12.5	2.7
Means	SR52	988.6	50.8	4.7
	HK	560.0	18.3	2.9

Notes: * Losses were given by farmer in Table 17
† Same letter denotes same owner

The importance of consumption data is clearly demonstrated by these results, those farmers storing the most grain suffering not only the highest weight loss but also the highest percentage loss. This is because they had maize surplus to their food requirements that was stored until the end of the season, prior to the next harvest. This maize suffered the maximum loss of 8 – 10% causing a disproportionate effect on the overall loss figures, pushing them up to 5 – 6%. A farmer storing just enough to last him over the season suffered a loss of only 3 – 4% because at the time of maximum loss he had only 5 – 10% of his total stored crop remaining. The mean percentage loss suffered by those farmers storing SR52 was higher than those storing HK type.

For the individual farmers the results show that the farmer who did not have enough maize to last him through the season (store 1) suffered a loss of only 1.7% compared with the farmer with four stores and a large surplus who suffered a loss of 5.6% over the period of the investigation. Although farmers storing HK type maize stored more than the others, except for the owner of the four stores, their losses of 3.0–3.5% per store were lower. These results refer to the period under investigation and relate only to that part of the crop removed from store during that period. However, grain removed prior to this would have experienced negligible loss because of the low infestation and dry conditions prevailing for five months after harvest. These losses can be compared with the results from Mt. Makulu and Chalimbana which were taken over the same period.

In most cases studied the careful choice of cobs for store evidently succeeded in reducing the losses to a level acceptable to the farmer, but there is an indication that losses could be higher in areas where less care is taken over storage. As the growing of hybrid cobs for home storage increases and the use of fertiliser leads to these becoming larger and more open at the tip of the sheath, losses can be expected to rise, especially if farmers keep a surplus until the end of the season. If this surplus was kept longer to offset a poor harvest then this particular portion could suffer losses of over 10%.

3. Chalimbana

Only one out of the ten farmers interviewed had sufficient maize in store for a continuous survey of loss to be made. His shelled grain was kept in a muddied store with removal from the top via an aperture immediately below the roof. The grain was treated with lindane but, as the loss estimates in Table 32 show, this was ineffective.

Table 32

Chalimbana: regression estimates of dry weight loss

Date	% Weight loss
9 October	0
23 October	0.08
6 November	0.58
4 December	1.35
18 December	1.84
31 December	2.96
15 January	3.13
29 January	3.38
12 February	5.51
26 February	7.42
12 March	10.94
26 March	12.95
9 April	11.42
22 April	8.58
Mean	5.01
Consumption corrected	5.7

The losses in the Table refer only to the period under investigation. The maize consumed by the farmer prior to the first sampling occasion probably suffered very little loss because of the conditions prevailing at that time of year. However, he still had about two bags of maize in store when sampling finished. This maize would be subject to losses of approximately 10% and possibly higher if the 'sump effect' occurred in the grain at the bottom of the store. A possible reason for higher losses than those observed at Mt. Makulu is the removal of grain from the top and the larger bulk in store, the losses being more comparable with the storage of maize on the cob.

The regression equation calculated for this store is similar to that for the Mt. Makulu cob stores, but with slightly less emphasis on the time in store.

$Y_c = 0.017\ x_1\ + 0.217x_2$

Y_c — % weight loss

X_1 — number of days in store

X_2 — percentage damaged grains

The total weight of maize removed would have been 1,410kg in the absence of loss. However, 80.3 kg was lost during the period investigated; an overall loss of 5.7%.

Quality loss

The farmers' assessment of quality changed as their supplies diminished — they accepted damaged maize for consumption more readily with an almost empty store than with a full one. They could also sell damaged maize privately more easily near the end of the season. (It could not be sold to NAMBoard during this period because rural depots were closed and in any case the moisture and damage levels were too high). To avoid this problem, of change in farmers' subjective assessments, quality was assessed objectively according to NAMBoards acceptance standards (Anon. 1970). Moisture content, however, was ignored since this criterion is imposed to facilitate the storage of purchased maize, not as an indication of its quality (Table 33).

Table 33

Standards used to determine quality

	Grade		
	A	B	C
Max % sievings	0.5	0.75	1.0
Max % insect damage	3.0	5.0	25.0
Max % moulding + other damage (excluding above)	5.0	10.0	20.0
Max % chipped grain	8.0	>8.0	>8.0

Table 34

Mt. Makulu: quality assessment

Week ending	*Shelled grain stores*					*Cob stores*			
	M1 Tr.	M2	M3 Tr.	M4	M5 Tr.	C1 – husks	C2 – husks	C3 + husks	C4 + husks
2 November	A	B	B	B	A	0	0	B	C
16 November	A	A	–	B	A	0	0	A	C
30 November	B	B	–	B	B	0	0	B	A
14 December	A	0	–	B	B	0	0	C	B
11 January	A	C	–	C	B	0	0	0	C
25 January	B	C	–	C	C	0	0	C	C
8 February	A	C	C	C	B	0	0	C	C
22 February	0	0	B	B	C	0	0	0	0
8 March	A	0	A	C	B	0	0	C	0
22 March	0	0	B	C	A	0	0	0	0
5 April	C	0	B	0	C	0	0	C	0
19 April	0	0	0	0	B	0	0	0	0
10 May	0	0	C	C	C	0	0	0	0
17 May	0	0	0	0	0	0	0	0	0

Notes: Tr treated
– no observation
0 ungraded

The cobs without husks in the Mt. Makulu stores failed to reach even the lowest grade at the start of the assessment because of excessive insect damage, and by December they were inedible. As opposed to this, when the first samples were taken from the stores in Chivuna, nearly all the samples were of Grade A as a result of farmers practising selection of cobs. These cobs were also of a higher quality than those with husks attached in the simulation stores (Tables 34 and 35). This applied throughout the storage season and one farmer maintained his maize consistently at Grade A. By the end of March all cobs in the simulation stores were ungraded.

Table 35

Chivuna: quality assessment

Date	No. of samples in grade A	B	C	Ungraded
11 October	7	1	0	0
25 October	13	0	0	0
8 November	9	3	1	0
22 November	9	1	2	0
6 December	9	2	2	0
20 December	8	3	2	0
4 January	6	4	3	0
17 January	3	3	3	0
31 January	4	2	6	0
14 February	1	4	7	0
28 February	2	0	8	1
28 March	1	3	4	3
25 April	1	0	3	2
9 May	0	0	1	2

Table 36

Chalimbana: quality assessment

Date	Grade — Store No: 1	2	3	4	5
9 October	B	A	B	A	–
23 October	–	–	C	A	–
6 November	A	B	A	A	–
4 December	–	–	–	A	–
18 December	–	–	–	A	A
31 December	–	–	–	C	C
15 January	–	–	–	C	A
29 January	–	–	–	C	A
12 February	–	–	–	C	A
26 February	–	–	–	C	–
12 March	–	–	–	0	–
26 March	–	–	–	0	–
9 April	–	–	–	0	–
22 April	–	–	–	0	–

Notes: – no observation
0 ungraded

The shelled grain put into store by Chalimbana farmers was classified as Grade A at the commencement of the assessment only in one of the four stores. This maize dropped in quality during December and became of a lower standard than that of farmers storing cobs (Table 36). The untreated shelled grain in the simulation stores was kept in a similar condition to maize in the farmers' cob stores. Grain in the treated stores was maintained at Grade B and C until the bottom layer was reached.

Reference has been made to the fact that when samples of cobs were taken these were shown to farmers to discover whether any would have been rejected. In practice, the extent of rejection was very low – only 0.8%. However, farmers were less selective towards the end of the storage season with a total of ten cobs being rejected until the beginning of January but only one afterwards.

Other forms of loss

Seed

The loss in maize stored by farmers for seed was negligible and was therefore not investigated. The main reasons for the very small storage losses are:

1. Farmers growing hybrid maize buy it just before planting, while those growing local types carefully select undamaged maize from their stores.
2. Considerable care is taken in cases where maize to be used for seed is stored separately, so that losses caused by rats are lessened.
3. Planting of seed normally precedes the rains when losses are heavy and follow the hot dry season in which conditions for maintaining its quality are good. This means that seed maize stored from the last harvest is unlikely to suffer any loss, and no farmer interviewed during the questionnaire surveys mentioned keeping maize intended for seed for longer than this.

Nutritional

Although this type of loss is undoubtedly important, no facilities for monitoring the nutritional status of maize were available to the project.

USE OF INSECTICIDE

The official recommended treatment for maize is the application of Blue Cross insecticide (Malathion) at the rate of one 100 g packet per 90 kg bag. This should give a concentration on the grain of 11 ppm. This treatment applies to shelled grain only as it is difficult to control storage insects on cobs with sheaths using insecticidal dusts. This is due to the lack of contact with the pest and quicker breakdown of the insecticide.

Samples of grain were taken in March from the stores at Mt. Makulu and analysed for malathion concentration. The results are given in Table 37. The figures are higher than would be expected for the treated stores and it was later discovered that the batch of Blue Cross used was 4.5% malathion instead of 1%, giving an effective dosage of 50 ppm when applied at the recommended rate. As anticipated, the store M3 which remained untouched until February retained the highest concentration of malathion. The minute residues in the untreated stores are probably from contamination of sampling equipment, bags etc. and are unimportant.

The field samples were also analysed for insecticide residues at the end of October after the farmers had been asked which insecticide (if any) they had used to treat their stored maize. The most common insecticide used by the farmers whose stores were sampled was Gamatox, a wettable powder formulation of 25% lindane used as a cattle dip and unsuited to storage application. One farmer used DDT as well. The results of the analysis of samples taken at the end of October in Chivuna and Chalimbana are shown in Table 38.

Table 37

Mt. Makulu: sample analysis for malathion residues in March

Store	Treatment	Malathion ppm
M1	+	12
M2	–	0.3
M3 (Long term)	+	20
M4	–	0.3
M5	+	16

Table 38

Chivuna and Chalimbana: analysis of samples for insecticide residues

Number		Date	Insecticide	Concentration ppm	Used Gamatox on maize according to questionnaire
Chivuna	1	25 Oct	Lindane	<0.02	+
	2	25 Oct	Lindane	<0.02	+
	3	25 Oct	Lindane	<0.02	+
	4	25 Oct	Lindane	0.02	+
	5	25 Oct	Lindane	0.03	+
	6	25 Oct	Lindane	<0.02	+
	7	25 Oct	Lindane	0.06	+
	8	25 Oct	Lindane	0.02	+
	9	25 Oct	Lindane	0.04	+ treated store floor only
	10	25 Oct	Lindane	<0.02	+
	11	25 Oct	Lindane	<0.02	+
	12	25 Oct	Lindane	<0.02	+
	13	25 Oct	Lindane	<0.02	+
Chalimbana	4	4 Dec	Lindane	10.4	+
	5	4 Dec	Lindane	13.0	+
			Other BHC possibly	>13.0	
			DDT	2.9	

A later analysis on the only store in Chalimbana still surveyed in April (Number 4) showed 2.4 ppm lindane, a trace of DDT and a large amount of other BHC isomers in a different ratio from Gamatox. This may have been due to the use of another formulation such as Agrisan 3 (another cattle dip) or due to weathering of Gamatox.

In all the samples of cob maize from Chivuna stored with the sheath on the residues were found to be negligible, although most farmers put approximately 1 kg of Gamatox in each store. Any dust used is usually lost on stripping the sheath and shelling. Insects infesting such treated maize would therefore only contact insecticide on movement between cobs in store. The population of insects in a cob infested in the field could build up and cause considerable damage in store before it was exposed to insecticide dusted on to the cobs and if this was Gamatox as applied by the farmers it would probably not kill them. During the questionnaire surveys farmers were asked which insecticides (if any) they had used. Their replies are shown in Table 39.

Table 39

Chivuna and Chalimbana: results of surveys on use of insecticides in storage during 1973–74

Area	*Grain*				*Cobs*			
	None	Gamatox	DDT	Other	None	Gamatox	DDT	Other
Chivuna:								
Intensive	0	0	0	0	6	14	0	0
Extensive	0	0	0	1 Blue Cross	22	41	1	3 Aldrin
Chalimbana:								
Intensive	3	4	3	0	0	0	0	0
Extensive	6	5	20	1 Blue Cross	5	1	2	0

The lone Blue Cross treatment for shelled grain in Chivuna was a small scale demonstration arranged by the extension staff. The similar Blue Cross treatment in Chalimbana was the farmer's idea but he had to travel 30 km to obtain the insecticide from Lusaka as it was not available in the rural depot. (A number of farmers complained to the authors on this point.) The farmer was completely satisfied with the result and wished to continue using Blue Cross. The three farmers using aldrin dusted it around the base of their store(s) and the support posts to control termites — one can only hope that they did not use it on their maize as it is not safe for use on food.

Over 75% of the farmers storing shelled grain use an insecticide indicating that they feel the need for insect-control although only one out of the 42 concerned used the correct one. Therefore given good distribution, it should not be difficult to persuade farmers to use the correct insecticide on their shelled maize if their losses warrant it.

Of those farmers storing cobs 66% used an insecticide, Gamatox being the most popular, whereas DDT was more popular for farmers storing shelled grain. The fact that proportionately fewer of the farmers storing cob maize used an insecticide than did those storing grain might indicate some resistance to change, especially where recommendations include not only insecticide but switching to a different type of store and shelling. It might be possible to encourage such farmers to store a proportion of their maize shelled for use after the onset of the heavy rains if their cob maize normally showed high levels of damage during this period and this was one reason why the long term store was used at Mt. Makulu. Before the rains they could continue to use maize stored on the cob.

Part 5

The economic evaluation of losses

INTRODUCTION

In Part 1 the general principles governing the economic evaluation of losses were examined. These are now applied to the specific case of the small farmer in Zambia using the data obtained in Part 4.

It is first necessary to define carefully the limits of our analysis. In particular, it must be emphasised that the values obtained are not for 'the' small farmer, but only for a selected number in two defined areas. It must also be remembered that the analysis is based on the findings of just one storage season.

To avoid confusion arising about the identification of individual farmers a notation of A, B, C, etc has been used for those in Chivuna. The relationship of each farmer to the particular stores in Table 31 (p 86) is summarised below.

Area	Farmer	No's used to identify stores in Table	Total number of stores possessed	Type/variety of maize stored
Chivuna	A	1	1	SR52
	B	2	1	SR52
	C	3 and 4	2	HK
	D	5 – 8	4	SR52
	E	9	1	SR52
	F	10 and 11	2	HK
	G	12 and 13	2	HK
Chalimbana	Not applicable	4	1	SR52

THE FARMER'S VIEWPOINT

Damage to stored maize may reduce both its quantity and quality.

Weight loss

The basis of evaluation is the attribution of a value to the intended use of the maize concerned which, because of its loss, must now be foregone. To discover what this use would have been it is necessary to consider the ways in which farmers consumed their maize. Information on this was obtained when farmers were visited for the purpose of taking samples (about every fortnight). On each occasion a farmer was seen he was asked about how much maize he had taken from his store since the last visit and the ways in which this had been used (p 85). A summary of the data collected from the seven farmers in Chivuna and one in Chalimbana is given in Table 40. It should be noted that these data cover the period from 9 October (Chalimbana)/11 October (Chivuna) either until a store was empty, or until 22 April (Chalimbana)/5 May (Chivuna). It does not therefore refer to the total quantity of maize put into store.

The table shows that, except in one case, more than 50% of a farmer's maize was used for food. Making beer was easily the second most important type of consumption and three farmers consumed more than 30% of their maize in this way. It is interesting to note that these percentages were generally higher than those found in the questionnaire surveys where no farmer admitted to using more than 15%. Six farmers, including two who stored only hybrid maize, used some for seed (This was also different from the findings of the questionnaire survey in which no farmer storing SR52 maize mentioned using any for seed). Two farmers gave some of their maize away. Only one farmer sold any maize, but the amount concerned was large; nearly 28 bags — 50% of his total usage. No farmer mentioned throwing any maize away.

One method of evaluating weight loss with this data would be to apportion it between the maize consumed as food, beer etc in the percentages which each use formed of the total. For example, in the case of farmer A it would be divided between food, beer and seed in the percentages 38, 56 and 6. This method would be suitable if farmers were unaware that their maize suffered damage, but this is not generally true as shown by the extent to which many take preventive measures in an effort to reduce it. A more realistic assumption is that damage is regarded, like a poor harvest, as a factor which reduces the amount of maize available. Consequently, a weight loss will normally be borne by that use (or usages) of a farmer's maize which is lowest in his order of priorities.

A small farmer stores his maize primarily to feed himself and his family. If he has sufficient to spare after doing this (and occasionally even if he has not) he will make beer. When a farmer considers he has sufficient maize in store to meet his requirements the surplus may be sold, normally to other farmers. In the case of gifts, the extent to which these are provided will depend partly on how much maize a farmer has available and also on the extent to which he is visited by needy relatives. Cobs for seed are selected from the store in November or December. Naturally, the best are taken and as already noted (p 85) this would normally preclude the possibility of their being damaged.

A farmer's priorities are strongly influenced by the time at which he is using his maize. Three distinct periods may be defined in conceptual terms, if not in actual practice. The first of these may be described as the 'euphoric phase' taking place immediately after harvest when, with his stock of maize at its maximum, a farmer will be relatively generous with its use and may make sales, gifts or barter. This stage gradually merges into one of 'belt-tightening' when he will become more careful, perhaps using for food a lower quality of maize which he would have previously used for other purposes. The extent and rate of the onset of this phase will depend on such factors as the size of his crop, how successful he has been in gauging his requirements, how many visitors he has been feeding and the extent to which his stored crop is being affected by damage. A farmer is traditionally visited by his relatives at Christmas and after this period 'belt-tightening' may become particularly marked. The last phase may be called 'pre-harvest' and occurs when a farmer knows approximately the size of his next crop and when it will be ready. Those farmers who still have some maize in store at this time will now be assured of a continuation of their food supply and may again commence making beer, gifts and sales.

Before these priorities are taken into account in evaluating weight losses an evaluation is made using a standard price since often, when a large number of individual assessments have to be made, this will be the only practical method to adopt. The price used in this case is the average at which farmers purchased maize during the 1973–74 storage season (Table 41).

Table 40

Chivuna and Chalimbana: consumption of stored maize by selected farmers (tins of shelled grain)

Farmer	No of stores possessed	Total quantity consumed – Tins	Food		Making beer		Seed		Gifts		Sale	
			Tins	Per cent	Tins	Per cent	Tins	Per cent	Tins	Per cent	Tins	Per cent
Chivuna – A	1	32	12	37.5	18	56.2	2	6.3	0	0	0	0
B	1	42	42	100.0	0	0	0	0	0	0	0	0
C	2	83½	43½	52.1	34	40.7	4	4.8	2	2.4	0	0
D	4	333½	106½	31.9	35	10.5	17	5.1	8	2.4	167	50.1
E	1	53½	33½	62.6	17	31.8	3	5.6	0	0	0	0
F	2	82½	61	73.9	14	17.6	7	8.5	0	0	0	0
G	2	62	53	85.4	5	8.1	4	6.5	0	0	0	0
Total (Chivuna)		689	351½	51.0	123½	17.9	37	5.4	10	1.5	167	24.2
Chalimbana	1	94	94	100.0	0	0	0	0	0	0	0	0
Totals (all farmers)		783	445½	56.9	123½	15.8	37	4.7	10	1.3	167	21.3
Mean of all farmers (to nearest tin)		98	56	57.1	15	15.3	5	5.1	1	1.0	21	21.4
Mean of Chivuna farmers (to nearest tin)		98	50	51.0	18	18.3	5	5.1	1	1.0	24	24.5

Note: Due to rounding, percentages may not total one hundred

Table 41

Chivuna and Chalimbana: maize transactions by selected farmers

Purchases						Sales*				
Date	Farmer	Reason for purchase	Quantity in bags	Value K's	Price K's per bag	Date	Farmer	Quantity in bags	Value K's	Price K's per bag
14 Feb	Chv. C	Making beer	1	3.85	3.85	20 Dec	Chv. D	⅓	1.20	3.60
28 Feb	Chv. B	Food	1	4.00	4.00	14 Feb	Chv. D	7½	27.00	3.60
12 Mar	Chalimbana	Making beer	1	4.30	4.30	28 Mar	Chv. D	3	12.60	4.20
28 Mar	Chv. C	Making beer	1	3.85	3.85	25 Apr	Chv. D	17	68.00	4.00
25 Apr	Chv. B	Food	1⅓	5.30	3.95					
Totals			5⅓	21.30	4.00(Mean)	Totals		27⅚	108.80	3.91(Mean)

*Where purchases or sales were made from more than one store these have been added together

Table 42

Chivuna: the evaluation of weight losses by farmer using mean purchasing price*

Farmer	Store(s) No(s).	Type/variety of maize	Dry weight loss kgs	Value of loss Total, K's	Per store, K's
A	1	SR52	8.2	0.36	0.36
B	2	SR52	34.6	1.54	1.54
C	3 and 4	HK	38.2	1.70	0.85
D	5 – 8	SR52	283.9	12.62	3.16
E	9	SR52	40.0	1.78	1.78
F	10 and 11	HK	41.1	1.83	0.92
G	12 and 13	HK	30.4	1.35	0.68
Totals			476.4	21.17	
Mean			68.1	3.02	1.63
Median			38.2	1.70	0.92

*K4.00 per 90 kg bag

Alternatively, the average price at which sales were made could have been used or the average price attained in both sales and purchases. This was not done since in the particular season in which the project operated purchases to supplement stored maize were considerably more common than sales. In fact since the average price obtained by the only one of the selected farmers to sell any of his maize was K3.91 per bag, the practical effect of using this figure instead of the K4.00 per bag for purchases would have been negligible.

Table 42 shows the values of weight losses calculated for farmers in Chivuna. These totalled K21.17 with a median of K1.70. One farmer with four stores incurred over half the total loss. The value of losses per store ranged from K0.36 to K3.16. The dry weight loss in maize stored as shelled grain is only available for one farmer in Chalimbana. This loss was 80.3 kg giving a value of K3.57.

In regard to the two types of maize stored the losses per store for HK type were normally lower than for the SR52 variety. The only exception to this was the case of farmer A; explained by the fact that his store was empty by the beginning of February.

Implicit in Table 42 and later calculations of weight loss is the assumption that the price used in evaluation is that for 90 kg of dry weight maize. In practice any maize that was bought (or sold) by a farmer would contain moisture and, if he wished to replace maize that had suffered a dry weight loss of x kg, he would need to buy x kg grossed up by the moisture content of the maize he bought. In the case of a loss affecting maize that was intended for sale grossing up would reflect the fact that a farmer would be selling wet weight. No adjustment has been made for this factor, partly since no data was collected on the moisture content of maize in farmers' transactions, but mainly because amendment to the estimates by the small magnitude involved — raising their value by a maximum of 0.62% would give them an impression of false accuracy. (This estimate of 0.62% is based on a moisture content of 14% — maximum — and a price of K4.00 per 90 kg).

An alternative assessment of weight loss is now made taking into account the attitudes of individual farmers. There is inevitably, room for differing opinions on what the sacrifice of maize meant for them individually and it must therefore be stressed that what is being considered is mainly a method of approach.

Farmers may be divided initially into those whose maize was not sufficient to last throughout the storage season and the rest. Three farmers A, B and G are in the first category.

As previously noted, farmer A had finished his maize by the beginning of February, partly because he chose to use some for beer. To the extent that he incurred a loss his maize was finished more quickly and would have had to be replaced as part of his first purchase after his store was empty. Accordingly, it is reasonable to value his loss at the price which he paid for this maize. Since this is not known the average price paid by farmers for their purchases is used.

The store of farmer B was empty by the beginning of April. His maize was used entirely for food and was supplemented by two purchases made at the end of February and in April. This loss may also be valued on the assumption that the maize concerned would have been consumed as food using the average price of K3.95 per bag which the farmer paid in April after his store was finished.

Table 43

Chivuna: consumption pattern for maize stored by farmer G (tins)*

Date	Total removed	Food	Making beer	Seed
8 Nov	6	6	0	0
22 Nov	4	4	0	0
6 Dec	4	4	0	0
20 Dec	8	4	0	4
4 Jan	4	4	0	0
17 Jan	4	4	0	0
31 Jan	6	4	2	0
14 Feb	6	3	3	0
28 Feb	4	4	0	0
28 Mar	8	8	0	0
25 Apr	8	8	0	0
Totals	62	53	5	4

*Total of two stores, both empty after 25 April

Table 44

Chivuna: consumption pattern for maize stored by farmer C (tins)*

Date	Total removed	Food	Making beer	Seed	Gifts
25 Oct	1	1	0	0	0
8 Nov	3	3	0	0	0
22 Nov	8	2	0	4	2
6 Dec	6	6	0	0	0
20 Dec	1	1	0	0	0
4 Jan	12	12	0	0	0
17 Jan	0	0	0	0	0
31 Jan	4	4	0	0	0
14 Feb	12	0	12	0	0
28 Feb	9	3	6	0	0
28 Mar	8½	8½	0	0	0
25 Apr	9	3	6	0	0
9 May	10	0	10	0	0
Totals	83½	43½	34	4	2

Note: Consumption refers to total of two stores: one store was emptied by 28 March, the other had some maize remaining on 9 May

The maize of farmer G lasted until 25th April and he did not make any purchases. However, as shown by his pattern of consumption in Table 43 he had little surplus maize at the end of the storage season to make beer or provide gifts, and therefore the most appropriate basis of valuing his loss is considered to be the average purchase price.

Of those farmers who had maize remaining in their stores at the end of the storage season only farmer D had sold grain. The others had made beer for their own consumption or sale, and had preferred to retain their surplus, perhaps as a safeguard against a poor harvest. In the case of farmer D the average price he received for his maize is used in valuation on the basis that if his loss had been lower he would have had that amount more maize to sell. Three of the remaining four farmers used increasing quantities of their maize to make beer as the season progressed, and an example of their pattern of consumption is given in Table 44. How much the sacrifice of maize which could have been made into beer is worth to a Zambian farmer must be a matter of conjecture. Fortunately, purchases of maize made expressly for this purpose were recorded and the actual price paid (or the average) is used. It may be noted that, at least in the period under review the amount paid for maize for making beer was, on average, no lower than that paid for maize to be used as food.

The farmer in Chalimbana who stored shelled grain used all his maize for food and still had some left at the time when he was last visited. If it is assumed that this maize would eventually have been eaten it may be valued as food, making a deduction to take account of its deterioration in quality. The evaluation of quality loss is considered in the next section. Using the method outlined there this maize is priced at K2.00 per bag.

Table 45

Chivuna: the evaluation of weight losses by farmer at opportunity cost

Farmer	Store(s) No(s).	Type of maize	Dry weight loss kgs	Value of loss	
				Totals, K's	Per store, K's
A	1	SR52	8.2	0.36	0.36
B	2	SR52	34.6	1.53	1.53
C	3 and 4	HK	38.2	1.63	0.82
D	5 – 8	SR52	283.9	12.33	3.08
E	9	SR52	40.0	1.78	1.78
F	10 and 11	HK	41.1	1.83	0.92
G	12 and 13	HK	30.4	1.35	0.68
Totals			476.4	20.81	
Mean			68.1	2.97	1.60
Median			38.2	1.63	0.92

Table 45 shows the valuation of weight losses incurred by farmers in Chivuna using the preceding paragraphs as a basis. Most values are the same or of a similar magnitude to those arrived at using the purchasing price. In the case of the Chalimbana farmer (not shown in the Table) the poor quality of the maize retained beyond the date of the last visit to him reduces the value of the loss in his store from K3.57 to K1.78.

The two alternative methods of valuation discussed will not always give similar results. The fact that they do so in the present case is largely dependent on the small range of prices within which maize transactions took place, and the absence of significant differentials in the prices of maize bought for different purposes.

Quality loss

Damage to stored maize reduces its quality. This may be assessed by the adoption of a grading system and applying it to the individual withdrawals of maize made by farmers. No system of grading is completely satisfactory and whichever is adopted will not necessarily reflect the subjective values of farmers themselves. That applied to maize sold to the NAMBoard in Zambia is governed by the National Agricultural Marketing (Acceptance Standards) Regulation of 1970 (Table 33, p 88). During the 1973–74 intake year Grade A maize was bought at NAMBoard rural depots at a price of K4.00 per bag, Grade B at K3.95 and Grade C at K3.85. After storage grades A and B are sold at a subsidised price to millers at K3.90 for making maize meal and beer, while Grade C is sold for stockfeed at K3.80. Regrading is carried out at NAMBoard central warehouses, so that maize which is bought as Grade B may be resold as Grade C. Any maize which is deemed below Grade C is sold for K2.00.

Trade opinion was sought in the United Kingdom as to what relative prices Grades A, B and C would fetch on the international market. On this basis Grade B would be sold at a discount of 3% but Grade C would be virtually unsaleable. Sales of grain between farmers themselves are normally within the price range K3.00 and K5.00 per bag but it may be assumed that, other things being equal, a higher price would be paid for a higher quality, although what the market could stand would also have to be taken into account.

In the absence of further information one, or a combination, of these systems have to be used. It has been decided to adopt that governing maize sales to NAMBoard, valuing Grade B maize at K0.05 below Grade A and Grade C at K0.15 below Grade A. Any maize below this quality has been valued at 50% of the price of Grade A.

The reasons for using this system of valuation are as follows:—

(a) The grading of sales to millers has not been thought appropriate since no distinction is made between Grades A and B. The reason for identical prices is partly because there is so little difference in the respective qualities, but also because the amount of Grade B actually sold is small relative to Grade A (about one tenth). However, it may be argued that if Grades A and B are of equal value they would be allotted identical prices when purchased.

(b) The standards of quality governing international trade are thought to be too high to be applied to small farmers living near subsistence level. This is particularly the case in respect of Grade C maize which would be valueless in trade but obviously not to farmers.

(c) The prices at which farmers themselves trade maize have not been adopted due to lack of sufficient information. Ideally, analysis of samples of maize taken from a number of sales would produce a criterion, but it is suspected that the price at which these sales take place would not be governed by quality to a sufficient extent for such an exercise to be helpful. In this respect, other factors taken into account in determining a particular price would be friendship (or otherwise) between buyer and seller, time of year and the degree of commercial instinct possessed by the transacting parties.

Having decided on an appropriate grading system it is necessary to ask whether it can be applied to all the maize consumed by a farmer irrespective of its particular use. In theory, different standards could be adopted for maize which was eaten, made into beer, used for seed, or sold, with the standard for gifts depending on the ultimate use of the maize concerned. This is not done due to a lack of information, for example about the nutritional value of maize consumed, and due to the practical difficulties involved.

Table 46 shows the grades of maize removed from stores in Chivuna. Table 36 (p 89) gave this information for the only farmer in Chalimbana whose maize lasted throughout the season. In Tables 47 and 48 the number of tins removed from stores in each grade are priced. Where a store had already been emptied at the time of a sampling visit so that no grade could be assessed, it has been assumed that the last amount of

Table 46

Chivuna: quality assessment of maize removed from individual stores

Farmer	A	B	C		D				E		F	G	
Type of maize	SR52	SR52	HK	HK	SR52	SR52	SR52	SR52	SR52	HK	HK	HK	HK
Store No.	1	2	3	4	5	6	7	8	9	10	11	12	13
11 Oct	A	A	A	A	A	A	B	A	–	–	–	–	–
25 Oct	A	A	A	A	A	A	A	A	A	A	A	A	A
8 Nov	A	A	B	A	A	A	B	A	A	B	A	C	A
22 Nov	–	A	A	A	A	A	A	A	A	B	C	C	A
6 Dec	B	A	A	A	A	A	C	B	C	A	A	A	A
20 Dec	A	A	A	A	C	B	A	A	B	A	B	C	A
4 Jan	C	B	B	A	C	A	B	A	B	A	A	C	A
17 Jan	C	B	C	A	–	–	–	–	A	C	B	B	A
31 Jan	E	B	C	A	B	C	C	C	A	A	C	C	A
14 Feb	E	B	B	A	C	C	C	B	C	C	C	C	B
28 Feb	E	C	C	A	C	C	C	C	C	C	E	O	A
28 Mar	E	O	O	A	O	C	C	C	B	C	E	B	B
25 Apr	E	E	E	A	E	E	C	E	O	O	E	C	C
9 May	E	E	E	C	E	E	E	E	O	O	E	E	E

Notes: O = below C Grade
— = no observation
E = store empty

maize consumed was of the same grade as on the immediately preceding visit. In some cases this will inevitably have over-estimated its quality and reduced the assessment of loss.

The sum of the values attached to the maize in each grade gives the total value of the maize removed from the store. If this is deducted from what it would have been if all withdrawals had been of Grade A then a measurement of quality loss is obtained. This is shown both as an absolute amount and as a percentage of the maximum possible value of the maize removed.

Quality losses assessed in this way ranged from K0.15 (0.7%) for HK type maize in store 13 to K15.51 (24.2%) for SR52 variety in store 5. The mean value for quality loss in all stores was K2.67 (median K1.62); for those containing only SR52 maize it was K4.54 (median K2.09) and for those containing only HK type maize it was K1.17 (median K0.75). In the case of the maize stored in grain form by the farmer in Chalimbana the loss was K11.83 (19.0%). Table 49 shows quality losses by farmer for those storing cobs.

The largest loss in absolute terms of K20.53 was suffered by farmer D who also incurred the heaviest loss per store. Percentage losses varied between 1.2% and 13.4% (farmer E). The median value of the quality loss per store was K1.87 (mean K2.68).

Maize used for making beer need not be of a high quality, so that the loss assessments made for those farmers who used some of their poor quality grain in this way are probably too high. It is impossible to judge the extent of this particularly since some maize actually made into beer might have been used for food if it had been of a higher quality. A calculation can, however, be made on the basis of ignoring quality loss in maize used for making beer, and the results are shown in Table 49 against the original assessment. The farmer in Chalimbana did not make any beer so that no adjustment needs to be made.

Table 47

Chivuna: evaluation of quality loss by store

Farmer	A		B		C				D								E	
Type of maize	SR52		SR52		HK		HK		SR52		SR52		SR52		SR52		SR52	
Store No.	1		2		3		4		5		6		7		8		9	
Grades of maize removed	Tins	K's	Tins	K's	Tins	K's	Tins	K's	Tins	K's	Tins	K's	Tins	K's	Tins	K's	Tins	K's
A	14	9.33	12	8.00	1	0.67	48½	32.33	17	11.33	5	3.33	8	5.33	11½	7.67	14½	9.67
B	12	7.90	22	14.48	13	8.56	0	0	2	1.32	4	2.63	4	2.63	11	7.24	13	8.56
C	6	3.85	2	1.28	7	4.49	10	6.42	33	21.17	82	52.62	76	48.77	36	23.10	13	8.34
Under C	0	0	6	2.00	4	1.33	0	0	44	14.67	0	0	0	0	0	0	13	4.33
(i) Totals	32	21.08	42	25.76	25	15.05	58½	38.75	96	48.49	91	58.58	88	56.73	58½	38.01	53½	30.90
(ii) Maximum possible value		21.33		28.00		16.67		39.00		64.00		60.67		58.67		39.00		35.67
(iii) Quality loss (ii)–(i)		0.25		2.24		1.62		0.25		15.51		2.09		1.94		0.99		4.77
Percentage quality loss		1.2		8.0		9.7		0.6		24.2		3.4		3.3		2.5		13.4

Farmer	F				G				Total farmers					
Type of maize	HK		HK		HK		HK		SR52		HK		SR52 & HK	
Store No.	10		11		12		13		1,2,5–9		3,4,10–13		1–13	
Grades of maize removed	Tins	K's	Tins	K's	Tins	K's	Tins	K's	Tins	K's	Tins	K's	Tins	K's
A	12	8.00	16	10.67	2	1.33	21	14.00	82	54.67	100½	67.00	182½	121.67
B	16	10.53	8	5.27	6	3.95	6	3.95	65	42.79	52	34.23	117	77.02
C	12½	8.02	9	5.78	21	13.47	4	2.57	248	159.13	63½	40.75	311½	199.88
Under C	9	3.00	0	0	2	0.67	0	0	63	21.00	15	5.00	78	26.00
(i) Totals	49½	29.55	33	21.72	31	19.42	31	20.52	458	277.59	231	146.98	689	424.57
(ii) Maximum possible value		33.00		22.00		20.67		20.67		305.33		154.00		459.33
(iii) Quality loss (ii)–(i)		3.45		0.28		1.25		0.15		27.74		7.02		34.76*
Percentage quality loss		10.5		1.9		4.9		0.7		9.1		4.6		7.6

Notes: (i) Grades are priced at the following rates (per bag), A – K4.00, B – K3.95, C – K3.85, under C – K2.00
(ii) One tin of maize is approximately equal to 15 kgs

* Due to rounding, this figure differs slightly from the sum of the individual assessments

Table 48

Chalimbana: evaluation of quality loss

Variety of maize		SR52
Store No		4
Grades of maize removed	Tins of shelled grain	K's
A	28	18.67
B	0	0
C	33	21.17
Under C	33	11.00
(i) Totals	94	50.84
(ii) Maximum possible value		62.67
(iii) Quality loss (ii) — (i)		11.83
Percentage quality loss		18.98

Table 49

Chivuna: evaluation of quality loss by farmer

Farmer	Store(s) No(s)	Type of maize stored	Quality loss Total, K's	Percentage	Mean per store K's
A	1	SR52	0.25 (0.15)	1.2 (0.7)	0.25 (0.15)
B	2	SR52	2.24 (2.24)	8.0 (8.0)	2.24 (2.24)
C	3 and 4	HK	1.87 (1.37)	3.4 (2.5)	0.94 (0.69)
D	5 – 8	SR52	20.53 (16.30)	9.2 (7.3)	5.14 (4.08)
E	9	SR52	4.77 (2.58)	13.4 (7.2)	4.77 (2.58)
F	10 and 11	HK	3.73 (2.11)	6.8 (3.8)	1.87 (1.06)
G	12 and 13	HK	1.40 (1.32)	3.4 (3.2)	0.70 (0.61)
Totals			34.79 (26.07)	7.6 (5.7)	
Mean			4.97 (3.72)		2.68 (2.01)
Median			2.24 (2.11)		1.87 (1.06)

( ) Value if quality loss on maize used for beer is ignored.

The values placed on the quality loss for individual farmers in Chivuna are reduced, except in one case where no beer was made, by amounts varying from KO.10 to K4.23 or, on a per store basis, by amounts from K0.10 to K2.19. The mean loss per store falls from K2.68 to K2.01 and the median from K1.87 to K1.06. If the adjusted figures are looked at in percentage terms the losses borne by farmers B, D and E who stored SR52 variety of maize are broadly comparable. The same is also true for the three farmers storing HK type.

Indirect loss costs

The two forms of direct loss have now been considered. However, as a result of past experience many farmers take preventative action aimed at reducing the damage which their maize suffers. Since these measures would not be taken if losses did not occur their cost needs to be taken into account in evaluation. As mentioned in Part 1 such costs may be termed indirect since they are not borne as a consequence of damage already incurred in a specific storage season. To the extent that the methods of prevention are successful the direct cost of loss will be reduced.

Table 50

Chivuna and Chalimbana: the cost of loss prevention

Farmer	Store(s) No(s)	Quantity of Gamatox used (max)	Cost* K's
A	1	1	1.55
B	2	1	1.55
C	3 and 4	2	3.10
D	5 – 8	2	3.10
E	9	0	0
F	10 and 11	1	1.55
G	12 and 13	2	3.10
Chalimbana	4	3	4.65

* The price of Gamatox is K1.55 per packet

All the selected farmers except one applied Gamatox to the maize which they put into store using a total quantity of up to three packets or, approximately, one per store. It is not known whether a complete packet was used in each case and, therefore the data in Table 50 which shows the cost of Gamatox to each farmer, represents his maximum expenditure.

Other ways in which farmers attempt to reduce damage are by thoroughly cleaning their stores before their maize is put in and, in the case of those storing cobs, by careful selection. It is likely, however, that some selection and cleaning would take place irrespective of the existence of damage, and it is not considered worthwhile to impute a cost to the time spent on these activities. In Table 51 quantifiable losses are totalled. Weight losses have been valued at the average purchasing prize of maize and, in respect of quality losses, no adjustment has been made for maize used for making beer.

The heaviest total loss of K36.25 was experienced by farmer D or, on a per store basis, by the farmer in Chalimbana. The loss per store ranged from a value of K2.16 for farmer A to K9.06 for farmer D. The mean loss per store for those farmers storing SR52 variety of maize in cob form was K7.18 and for those storing HK type

Table 51

Chivuna and Chalimbana: the evaluation of total losses by farmer (in Kwacha)

Farmer No.	Store(s) No(s).	Type of maize	*Total loss* Per store	*Total loss* Gross	Total direct loss	*Direct Loss* Weight	*Direct Loss* Quality	*Indirect loss*
(i) Chivuna (cob storage)								
A	1	SR52	2.16	2.16	0.61	0.36	0.25	1.55
B	2	SR52	5.33	5.33	3.78	1.54	2.24	1.55
C	3 and 4	HK	3.34	6.67	3.57	1.70	1.87	3.10
D	5–8	SR52	9.06	36.25	33.25	12.62	20.53	3.10
E	9	SR52	6.55	6.55	6.55	1.78	4.77	0
F	10 and 11	HK	3.56	7.11	5.56	1.83	3.73	1.55
G	12 and 13	HK	2.93	5.85	2.75	1.35	1.40	3.10
		Totals		69.91	55.96	21.17	34.79	13.95
		Mean	5.38	10.00	8.01	3.02	4.97	1.99
		Median	3.56	6.55	3.57	1.70	2.24	1.55
(ii) Chalimbana (Grain storage)								
Not applicable	4	SR52	20.05	20.05	15.40	3.57	11.83	4.65

K3.27. With the exception of farmer A, quality losses were greater than those suffered due to loss of weight. However, there was no consistent pattern of one form of loss being the highest in all cases. If the lower values for weight and quality losses are taken — ie those obtained on the basis of opportunity cost and of ignoring the loss in quality in maize used for making beer — reductions of more than one kwacha occur in respect of the losses experienced by four farmers; that of farmer D falls by K4.52 (K1.13 per store), that of farmer E with one store by K2.19 and that of farmer F by K1.62 (K0.81 per store). The loss of the farmer in Chalimbana (with one store) is reduced by K1.78. Most of this variation reflects the lower valuation put on quality loss.

Before concluding this discussion of values it is worthwhile stressing that, by the nature of the analysis, the economic evaluation of loss can seldom result in an indisputable assessment. Consequently, the amounts quoted in this report can best be viewed as indicative of orders of magnitude.

Other costs

Nutritional loss is an important, though not easily quantifiable, cost suffered by farmers. This is not a loss in the same sense as the others that have been considered since, as such, it does not affect the economic value of maize. To the extent that nutritional loss occurs its impact will be felt near the end of the storage season and a farmer will either suffer it or have to consume a greater quantity of maize to obtain the same value of nutrients. Without further data it is not possible to say whether nutritional loss is of sufficient importance in this particular case to operate as a drain on farmers' energy, and therefore affect their capacity to work.

Questions were put during the questionnaire surveys on the influence of storage damage on farming behaviour, for example, 'If your maize suffered less damage would this alter the amount which you stored?' Insufficient information emerged from this type of enquiry for any useful conclusion to be drawn but, due to the relatively low levels of damage found, any significant influence on the quantities of maize sown or stored is unlikely. However, there was a very definite realisation amongst farmers that hybrid maize is more susceptible to damage than HK or local type. This must act as a limiting factor on the amount of each type stored and possibly on the overall quantity grown.

THE SOCIAL VIEWPOINT

General considerations

It is difficult to discuss the impact of losses on the country as a whole without knowing to what extent the behaviour and experience of those farmers visited are representative. In the following paragraphs it is assumed, that it is sufficiently comparable for general statements to be made about 'the small farmer'. However, it must be remembered that these are based on a study of only a very limited number.

The practical effect of losses of the magnitude experienced by the selected farmers on the Zambian economy would be slight. This is because the consequences of such losses are borne mainly by the farmers themselves. For example, if their loss is sufficient to warrant their purchasing maize these purchases are often made from their neighbours. Alternatively, their need may be satisfied by receiving help from relatives. It is true that in this case the seller or giver would then have less maize, but normally this would not have entered commercial channels, being used to make beer, for barter, or possibly retained as a form of security. To a certain extent a loss may also be borne by a farmer reducing his consumption. Finally, since most sales to NAMBoard are made before storage takes place, losses in the quality of maize in store only directly affects the farmer consuming it, although to the extent that this may impair the effort which he puts into his farming, and thereby reduce his harvest and sales, others may also experience a loss.

Despite the fact that during the season those small farmers visited were, to a considerable extent, self sufficient in their maize requirements, their losses still represent a diminution in the quantity and quality of maize available in the country. In the way explained in Part 1 these may be valued on the basis of border prices adjusted, so far as possible, to take account of the cost of transporting the maize to/from the farmer.

Before proceeding to evaluate losses two simplifying inter-related assumptions need to be made. The first is that maize produced in Zambia during the 1973 harvest was all used within the period of the project. Strictly, the effect of storage losses during the 1973/74 season cannot be assessed until a subsequent period, when it is known to what use the particular maize would have been put. This assumption is not however, very unrealistic since it is reasonable to suppose that in making a decision whether to import or export maize, the relevant body, NAMBoard, takes into account mainly what is expected to happen in the current year. The second assumption follows from the first, namely, that if maize is exported in a particular year the country is assumed to have a surplus and, if imported, a deficit. In the first case a loss would therefore be valued on the basis of potential exports sacrificed and in the second on the extra imports needed.

Weight loss

Provisional estimates prepared by the Central Statistical Office in Lusaka showed that in 1973 Zambia exported 50.1 thousand tonnes of maize at a value of K52.8 per tonne or K4.75 per 90 kg. Virtually all exports went to Zaire. The cost of transporting maize to the border from Lusaka by rail depends on the quantity being moved at one time but is approximately K1.71 per tonne. This rate, however, reflects a subsidy of about 40%, so that the economic price is K2.39 per tonne or K0.22 per 90 kg bag. In the case of maize from Chivuna an addition of K0.11 per bag needs to be made to reflect moving the grain from the Southern Province, giving total transport costs from this area of K0.33 per bag. A final allowance needs to be made for the costs to NAMBoard of handling maize. The overall total of these depends on the level of maize intake in a particular year. However, an estimate obtained from NAMBoard put them at an average of K0.60 per bag.

If these transport and handling costs are deducted from the border price the net figure obtained is K3.93 per bag in the case of maize from Chalimbana and K3.82 per bag for maize from Chivuna. Ideally, these costs should be adjusted to take account of the fact that some reflect imported goods and that other items are not accorded their true economic value. However, it is doubtful if such adjustments are of sufficient importance in a study of this type to justify a collection of the very detailed data that would be needed. Consequently, in valuing weight losses from the social viewpoint all that has been done is a simple deduction of costs from the unit value of exports.

Quality loss

In determining the value of quality loss the standards mentioned earlier relating to maize entering international trade may be used ie in percentage terms Grade B would sell at three per cent below Grade A. This assumes that Grade B would find a market. In fact in 1973 sales to Zaire were all of Grade A, and it is possible that Grade B would have been unacceptable. A further problem relates to Grade C. Since this maize could not be sold in international trade the domestic standards of NAMBoard must be used. This is reasonable on the basis that for the country to make use of its surplus maize some Grade A maize which would have gone to the domestic market would have to be diverted, thus depriving domestic consumers of the extra quality.

Quality loss can therefore be assessed on the basis of the following prices: Grade A maize K3.82 per bag (K3.93 Chalimbana) and Grade B 3% below this at K3.71 (K3.81). For maize of Grade C and below the same differentials are used as when valuing quality losses of the individual farmers so that these are priced at K3.67 (K3.78) and K1.91 (K1.96) respectively.

Indirect costs

The price of Gamatox insecticide to farmers is not subsidised and adequately reflects its border value plus an allowance for transport and other costs involved in moving it to the farmer. No duty is payable and therefore the values in Table 50 may also be taken on a rough basis to represent social costs. A summary of social costs is given in Table 52.

Table 52

Chivuna and Chalimbana: the social cost of losses (Kwacha)

	Total direct + indirect costs	Total direct costs	Direct Weight	Direct Quality*	Indirect (insecticides)
Chivuna	68.93	54.98	20.22	34.76	13.95
Chalimbana	26.12	21.47	3.51	17.96	4.65
Total	95.05	76.45	23.73	52.72	18.60
Mean all farmers	11.88	9.56	2.97	6.59	2.33

* Calculated by the same method as for individual farmers

The total social cost of the losses incurred by all farmers is K95 (to the nearest Kwacha), made up of K76 direct costs and K19 indirect. The value of K19 for indirect costs is only approximate since, as noted earlier, the exact quantities of insecticide used by farmers are not known. The mean value of the direct loss is K9.56; with the exclusion of the Chalimbana farmer it would be K7.85.

Taken in isolation these figures have only a limited usefulness and should be viewed as a basis on which to compare losses in maize occurring during storage by small farmers with those that may take place elsewhere, for example during transport, or storage by NAMBoard. They may also be used, albeit with care, as guides to the urgency or otherwise of government action.

Other costs

Other social costs of losses arise from efforts made to minimise them. Examples of these are the extension staff employed to train farmers, research efforts aimed at producing less susceptible seeds and better methods of storage, foreign exchange spent on importing knowledge of new techniques and costs of grading and inspecting maize. None of these costs arise solely due to losses in store and the proportion to be attributed to them would be very difficult to determine. Nevertheless their existence needs to be remembered.

Part 6

Costs and benefits of an improved storage system

The main purpose of this part of the report is to evaluate the costs and benefits for the small farmer of storing his maize in the way recommended by the Ministry of Rural Development in Zambia. However, attention is first given to the principles of such an assessment, and the general costs and benefits that need to be considered.

PRINCIPLES OF ASSESSMENT

There are two basic approaches to measuring the value of a system of storage. One uses total costs and either compares these under different storage methods or relates them to the value of produce when it leaves the store. An example of the application of this technique is provided by Upton (1972) who assessed the costs and returns from a maize storage (and drying) project in Nigeria. In this case maize grains were stored in two concrete bins. Total costs were divided into depreciation, cleaning, treating the grain with BHC, fumigation and handling. These costs (and those of drying) were compared with the difference between the purchase price of the maize and its sale value after adjusting for a 6% drying loss and a 1.2% insect damage loss. The margin of revenue over costs was expressed as a rate of return on net capital costs (ie after depreciation), which included the cost of the maize. The period of storage was eight months.

Apart from the merits of this particular study, this type of approach is useful in taking into account all known costs, and it may be employed when comparing fundamentally different stores. The kind of situation in which this approach could be used occurs when a storage system is first introduced, or when radical alterations are being considered. The method presupposes that all costs are either known or are easily ascertainable. It is also of help when alternative stores having different lives are being considered. The produce removed from each may be regarded as a flow of goods which can be valued on an annuity basis in the same way as with a revenue stream from any other form of investment.

The alternative approach to evaluation is that of comparing the extra or marginal costs arising from introducing changes with the expected benefits. This method, adopted in the present study, is most useful where it is wished to discover whether certain modifications to existing storage techniques would repay their cost. In this connection the term 'economic injury level' has arisen; this links the cost of an improvement, such as an input of insecticide, to the value of grain saved. The point at which these are equal is the economic injury level and beyond this point further treatment will not be profitable. This concept was used by de Lima (1973) in a study of a number of grain storage projects amongst subsistence farmers in Kenya. The costs involved were those of the insecticide and sprayers; benefits were based on the amount of grain that would have been saved, had all the grain treated at harvest remained in store. The value of grain saved was divided by these costs and expressed as a benefit/cost ratio. It was considered that the ratio in that study had to be greater than two in order 'to allow for the variabilities present in this essentially biological exercise.'

Another reason for using the marginal approach is that the cost of a storage system can be difficult to assess. This may be because a large number of units are being considered and it is not practical to obtain the relevant information for each. Also, it may not be easy to put a reliable value on some of the inputs going into the construction of a store. An example of such inputs are 'free goods' obtained from the bush. The costs of these are dependent on the ease with which they can be gathered and this may vary from farmer to farmer.

Linked to the problem of which basic approach to adopt is that of how to relate costs and benefits once these have been ascertained. In this respect, the rate of return concept used in assessing industrial profitability will not normally be helpful, since what is relevant from a farmer's point of view is not the question, 'Shall I invest in storage or in something more profitable?' but, 'Is this particular storage system (or modification) worthwhile?'. Sometimes the answer to this type of problem may be expressed in terms of minimising costs and relating this to the level of damage. This is illustrated in the following example.

A farmer has a choice between two alternative storage systems. The total costs for types A and B with a capacity of 1,500 units are £100 and £120 respectively. The produce to be stored is used entirely for feeding cattle and, if damaged, it has to be thrown away, having no residual value. Damage to produce stored under system B is lower and 1,200 units can be used as opposed to 1,100 for A. The respective cost-benefit ratios are A 1:11 and B 1:10 showing that, at first glance, the extra cost of B is not worthwhile. Whether this is actually the case will depend on whether 1,100 units are sufficient to meet the need and, if not, whether the cost of the extra 100 is greater or less than £20.

To state the problem in this way would usually be of more assistance to a farmer than to quote that the two rates of return are, for example, 9% and 10% respectively, although the same argument would not necessarily be true of a decision having to be taken by a government about investing in storage facilities as opposed to something else. There may also be circumstances in which a rate of return may have to be calculated by a farmer, such as when putting in an application to obtain credit. A further difficulty involved in the rate or return approach is in deciding which costs should be included in arriving at the figure to which to relate benefits. For example, in Upton's study it is arguable that the cost of the maize should have been excluded.

The cost-benefit approach also needs to be used with care and simply quoting a ratio is insufficient as a guide to which storage system to adopt without considering other aspects of the problem as well. For example, from the point of view of the farmer the cost of a particular improvement may be too high, even if the ratio is favourable, and he may prefer something cheaper with lower potential benefits. Also, changes in storage methods may also involve him in too much work, particularly if this is at a season of the year when he is busy. From the point of view of a country, improvements using domestically produced equipment may be preferable to those needing imports, both on grounds of generating employment and in order to save foreign exchange. A government's priorities in this direction can be taken into account by using a system of weighting in which some benefits or costs are valued at more or less than unity. However, such an approach needs to be fully justified since by changing values in this way results can be 'tailored' to meet special requirements.

COSTS AND BENEFITS

The farmer's viewpoint

Costs

The most obvious cost of an improvement to a farmer is his financial outlay on new equipment, insecticide etc. For purposes of evaluation such items should be costed at the amount which he actually pays. To this amount should be added any interest payments on credit received. In cases where payment for improvements is spread over a number of years it will be necessary to employ a discount procedure, so that both costs and benefits are valued on a common basis. To the basic cost of equipment should be added any ancillary costs necessarily involved such as transport, insurance, spare parts, servicing and repairs.

The costs of improvements also include the value of time spent in their application and an important aspect of this question is the season when improvements are being applied, since the sacrifice or opportunity cost for his labour will depend on alternative demands for his time, eg there would be a high opportunity cost at harvest time. The extent to which a value should be placed on 'spare time' when a farmer has no farming work to do is arguable and in this respect even subsistence farmers may undertake activities such as craft work, cattle herding, village obligations and beer making. In theory, the intensity of effort required to apply improvements should also be taken into account in evaluation; it being reasonable to suppose that farmers prefer to work less hard if possible. This applies particularly in situations where there are some constraints on effort such as malnutrition or high temperatures. In practice, any such assessment would almost certainly have to be a subjective judgement based on observed behaviour.

Another important cost is that involved in learning to use new methods. In a developed economy where a basic education is the prerogative of all this will be relatively low. In developing countries where farmers may only be able to read and write to a very limited extent the cost involved both in time and effort will be heavy, particularly if it involves going to a training centre some miles distant without transport. Linked to this cost is that of the costs involved in trying new measures, and also that of their mistaken application. This will again apply more forcefully to farmers in developing countries, and the lower their level of education and training the less will be their readiness to experiment with innovations. For them change is not something to be undertaken lightly and in many instances their criteria will be minimum risk, particularly when the improvement being recommended affects a basic foodstuff which is an important part of their diet.

Lastly it should be emphasised that when assessing costs, in many cases it will be their net or marginal value that is relevant. Any existing method of storage will already involve time, effort and probably expenditure. Consequently, for most farmers the question will be 'What extra do I have to do or spend?' and if the extra benefits outweigh this the change may be adopted.

Benefits

These have been enumerated in Part 1, so that they will only be briefly listed here.

Improvements in storage can result in a higher proportion of a stored crop being available for use both in terms of its quantity and quality. A farmer may also be able to plan ahead with greater certainty, allowing himself the possibility of putting less of his crop into store, making more use of sales opportunities or simply having greater peace of mind that his family will not be short of food. The value of this benefit would depend on the extent of damage he currently suffered and would be greater following a poor harvest when it would be important for a farmer to preserve his whole crop. A farmer may also save money by not having to buy produce to replace his damaged crop, and in the long term an improvement in his basic nutritional standards may take place if the stored product is a basic foodstuff. Another benefit which may accrue to a farmer is that he may be able to store a variety of crop which was previously too susceptible to damage, or even to be able to store an entirely different crop from which he had been precluded. A reduction of storage pests will also help a farmer's crops in the field since these can be infested from insects flying out of the store. In the case of a crop which is then stored there is a 'build-up' effect. From the point of view of the commercial farmer benefits may take the form of lower unit costs possibly permitting an expansion of his activities. Where storage damage has been a limiting factor, for example, in growing a particular variety of crop improved storage practice may also allow this to take place.

In determining the benefits of improvements it is necessary to ask to whom these will accrue. For example, more complicated measures will generally assist better educated farmers, and expensive equipment those who have, or can obtain, enough money to buy it. Similarly, changes needing more than a very small labour requirement will help commercial farmers and those with larger families. In contrast, subsistence farmers may be helped by preferential treatment such as by subsidisation of their insecticides but not those of large scale farmers.

A further question needing to be asked in assessing benefits is their degree of certainty since in some cases a small, though almost definite, benefit may be preferred to a greater, more uncertain one.

The social viewpoint

Costs

The costs to the country as a whole of an improvement in a system of storage will be dependent on the agricultural situation into which it is being introduced. At one extreme costs may be negligible, for example, if it is being sold by a private profit making firm to commercial farmers and no question arises of any state assistance. On the other hand, costs may be appreciable where equipment and 'know-how' have to be imported, or if materials are sold to untrained farmers at subsidised prices. The first of these situations approximates to what occurs in many developed economies (although some subsidies, such as investment grants, may be given), while the second applies to a greater or lesser extent to the rural sector in many developing countries.

Which cost is the most significant will depend on the actual improvement concerned, but in developing countries this will often be that of motivating farmers to change their habits. It is important to realise that this may not simply be represented by the time taken to encourage and train farmers, but also the time taken to teach those who give the training. If this necessitates 'importing' personnel, a foreign exchange cost is involved.

The attempt to encourage farmers to use new measures may absorb a significant proportion of the time of extension staff, such as those in Zambia. These may be few in number and already have sufficient work to occupy them. Consequently, it is important to ask whether existing storage methods are sufficiently poor for efforts at changing them to have a priority claim, and also if this activity is the best use of these resources. An important factor in determining this question will be farmers' motivations and government intentions towards the future direction of the rural sector.

In this context an alternative measure to improving storage at farm level may be to encourage farmers to sell, soon after harvest, a higher proportion of their crop, which can then be stored centrally. Usually, this requires the setting up of an organised marketing system with fixed purchase prices to encourage farmers to sell and fixed resale prices which, while designed basically for consumer protection purposes, act as a disincentive to farmers to hold surplus stocks in anticipation of selling later on a high price market. The case for centralised storage as against farm storage has to be considered in relation to many factors, for example, its high capital and operating costs, its technical efficiency, the social system, national self-sufficiency etc.

Benefits

Some of the possible direct benefits of improvements in storage are: a greater quantity of the stored crop being available for use; the same quantity becoming available at a lower cost; an increase in quality. Other benefits may be a stimulation of employment and an increase in farmers' incomes. The extent to which the country as a whole benefits from such improvements will depend on their scale, the type of foodstuff concerned and the extent of integration of the farmers in question with the rest of the economy. In the case of subsistence farmers they, themselves, are likely to be the main beneficiaries. On the other hand, if the costs of commercial farmers are reduced and their profits increased, they may expand their output to the benefit of domestic consumers and possibly, by way of a reduction of imports, to the balance of trade.

Any significant changes in a storage system throughout a country may well have repercussions on those parts of the economy closely linked to the farming sector such as transport and distribution. For example, an appreciable reduction in losses may reduce the need to move food to rural areas; a benefit of particular relevance in view of increasing fuel costs and poor roads in many developing countries. Also, if nutritional standards are improved, scarce medical resources would be made available for other uses. Although these repercussions are beneficial, it is necessary to remember that the potential benefits of storage improvements can also pose problems, for example, by assisting farmers at the expense of some distributors whose services may no longer be required. There may also be, in some cases greater incentive for farmers to hold back supplies of a commodity to stimulate price rises.

Circumstances can be envisaged in which the net benefits of changes in storage may be great or virtually non-existent. In any analysis it is therefore necessary to proceed with caution and not to come to a conclusion in favour of change until all the possible consequences have been taken into account.

ASSESSMENT OF AN IMPROVED STORAGE SYSTEM IN ZAMBIA

The farmers' viewpoint

The recommendations made by the Ministry of Rural Development for storing maize by small farmers are as follows:

(a) storage should be in grain form

(b) stores should be muddied both inside and out

(c) 'Blue Cross', insecticide (p 90) should be added when storage takes place.

The improvements open to those farmers storing maize on the cob were shelling, the use of muddied stores and the addition of Blue Cross. For those already storing their maize as grain in muddied stores only the use of Blue Cross was needed to fulfil the recommended conditions.

As mentioned in the introduction to this report it was, unfortunately, not possible to obtain a cost-benefit ratio for the recommended method of storage in the field and therefore this is calculated using the results obtained for the simulation stores at Mt. Makulu (Part 4). Calculations are based on the quantities of cobs and grain put in the stores at Mt. Makulu ie ten bags of cobs and seven bags of grain. In the case of the grain stores only the results found for M4 (untreated grain, removal from the bottom) and M5 (treated, removal from the bottom) are used since those of other stores are insufficiently reliable for further analysis. In the case of the cob stores the losses found in C3 and C4 are taken since both of these contained cobs with husks attached. As shown by the replies to the questionnaire surveys (p 45) this method of storage was far more common than cobs without husks.

Costs

Since improvements are based on existing storage structures, the only essential item of financial outlay for a farmer is Blue Cross insecticide. This can be bought at a price of K0.10 a packet containing a quantity suitable for treating one 90 kg bag of shelled maize. The cost of treating the muddied stores at Mt. Makulu was therefore K0.70. In the case of the cob stores the cost may be based on grain equivalent and would have been K0.40 for store C3 or C4. To the cost of the Blue Cross itself needs to be added the value of the time needed for its application. This was about 3 to 4 minutes per bag, making a total, depending on the store, of between 12 and 28 minutes.

An accurate time for shelling was very difficult to obtain. Attempts were made during the questionnaire surveys to obtain information on this point but the times given by farmers were too diverse to be of any help. One problem is that the time taken depends on whether shelling is done by hand, with a stick, with a hand sheller or with a tractor driven sheller (used by a few farmers). A second problem is that shelling is a job often partly done by a farmer's wife and children. The estimate of time used in this report is taken from a German study (Gesellschaft für Regionale Strukturentwicklung 1971) and is for shelling with a stick. Most farmers visited in the project surveys said that their own shelling was done by hand, but this was as opposed to using some device such as a hand sheller, so that in many instances a stick would in fact have been used. The time quoted in the study (Appendix p 119) was eight hours and related to the period in which 5 to 6 people shelled 25 to 30 bags of maize cobs (data were given in terms of bags of shelled grain — ten — which has been converted). Ignoring the intensity of effort and the efficiency of people of different sex and ages this may be restated as one person taking approximately 1.3 to 1.9 hours to shell one bag of cobs. In terms of the quantities involved in the present case the ten bags of maize in cob form would be shelled in about 15 hours (1½ hours per bag).

The remaining operation to be considered is that of mudding. The total time spent on this naturally depends on the size of the store. It will also depend on the number of coats put on. Usually this is two, but a quick third coat may sometimes be applied. Mudding operations on the Mt. Makulu stores were timed. Initially, the builder worked at a leisurely pace and took about 12—14 hours to apply two coats. Operations on later stores proceeded more quickly and the total time taken for up to three coats was 7—9 hours. Therefore, it seems that an estimate of 8—12 hours is reasonable, amounting to 1—1½ days work. Sometimes a little remudding needs to be done during the rainy season, though this would only be a matter of a couple of hours work. The time needed to obtain and transport the preferred soil (from termite hills) would necessarily vary with the site of the farm but a day of 8 hours should be a sufficient allowance for this.

An estimate of the time needed to apply the recommended improvements is given in Table 53. It is based on the conversion of 10 bags of cobs into treated shelled grain. Where appropriate both minimum and maximum estimates are given to provide parameters. For example, in the case of shelling the two used are 1¼ and 1¾ hours per bag.

Since minimum rates are laid down for a number of occupations in Zambia (including agriculture) the most obvious way of costing this time is to apply the rate of pay given for similar work. At first this would seem to be that of K0.70 per day

Table 53

Storage improvements: estimate of the time needed for application

Operation	Time in hours	
	Minimum	Maximum
(1) Mudding:		
Obtaining materials	8	8
Application	8	12
Remudding	0	2
Sub Total	16	22
(2) Shelling	12½	17½
(3) Application of Blue Cross	¼	½
Total	28¾	40

(equivalent to about K0.08 per hour), received by agricultural labourers. If this is done the assumption is made that this represents the value of the farmer's time spent in applying the improvements. The justification for this rests on a consideration of:

(a) the availability of work off his farm.

(b) whether the farmer is free to do it.

(c) the suitability of treating this type of work as the alternative occupation engaged in by farmers.

(d) the possibility of a farmer's preference for leisure instead of improving his store or doing other work.

The availability of work other than farming depends, to a large extent, on where a farmer lives. In terms of the two areas of the project more was available around Chalimbana than Chivuna and a higher proportion of farmers there had outside interests. Much of this work would be done when comparatively little needed doing on the farm, roughly in the periods January to March and August to October. Moreover, on the evidence of the questionaire surveys, and from personal observation, the most important months for building stores were May, June and July and, since improvements would be applied at this time, it is reasonable to suppose that a farmer would then be resident on his farm anyway and not need to sacrifice any work which might have taken him away.

Basically two kinds of work were mentioned by farmers. The first was that in which the farmer was self-employed, such as carpentry, yoke making (for oxen), dealing in animals (cattle and poultry) and basket making. The other was mainly general labouring and driving vehicles. The self employed type of occupation was the most common and since in most cases it would have been done on or near the farm, is likely to have been the only type practised between May and July. A reasonable rate at which to cost the sacrifice involved in giving up time spent in this way is that of KO.16 per hour paid for unskilled labouring and general work.

It is unlikely that the time a farmer spent on improving his store would compete to any significant extent with his leisure, which is normally taken in the afternoon after work for the day has finished. Consequently, the rates to be applied in costing time can be confined to the range of K0.08 to K0.16 per hour.

Whereas the obtaining and application of mud, and the use of Blue Cross would be done by the farmer, shelling is mainly the job of his wife and family.

It would therefore be incorrect to apply the same imputed wage rate to the whole of the time spent in this activity. If it is assumed that one fifth of shelling is done by the farmer himself the rest of the time may be treated as a free good, being done by the wife and family in their spare time. This assumes a zero opportunity cost for the wife's work, which may be considered too low in view of the many tasks which she has to do. Accordingly, in fixing the upper costing limit a rate of K0.04 per hour has been used representing 50% of the rate paid for an agricultural labourer.

The relevant rates may now be applied to the time spent on applying storage improvements, and Table 54 sets out the calculation involved. This is done both on the basis of minimum and maximum costs. These total K1.56 and K4.80 respectively. Which of these estimates is the most appropriate will depend on the particular farmer. The minimum costs assume that if he was not improving his store he would be engaged entirely in other agricultural pursuits, maximum that he would otherwise be entirely engaged in self employment. A position between these two extremes may also be taken making what is considered the most realistic assumptions — a mean of the two estimates of the time taken in shelling and mudding (but including remudding), assuming that a wife's labour is free and adopting a costing rate of K0.10 per hour for the farmer's labour on the basis that between May and July he would spend about 75 per cent of his working time on farming activities. On this basis total costs for a farmer currently storing his maize in cob form would be K2.40. To this amount needs to be added the cost of the Blue Cross itself so that the total costs of storing

Table 54

The cost of time spent on an improved system of storage

Operation	Time taken (hours)		Rate for costing(k)		Cost (k)	
	Min	Max	Min	Max	Min	Max
(1) Mudding:						
Obtaining materials	8	8				
Application of mud	8	12				
Remudding	0	2				
Sub Total	16	22	0.08	0.16	1.28	3.52
(2) Shelling:						
Farmer	2½	3½	0.08	0.16	0.20	0.56
Wife/family	10	14	Free	0.04	–	0.56
(3) *Application of Blue Cross	¼	½	0.08	0.16	0.08	0.16
Total	28¾	40	–	–	1.56	4.80

*Costed at rate for one hour

the cobs in stores C3 and C4 in the recommended way would be K2.80. In the case of a farmer already storing grain his costs would be only K0.80—the purchase of Blue Cross insecticide plus the time spent on its application.

It should be noted that the estimates of cost given are gross. Where a farmer was already using Gamatox or DDT he would save the amount being spent on these. This has not been taken into account in the assessment since the application of an insecticide other than Blue Cross is not an alternative treatment and no other insecticide was therefore applied to any of the stores at Mt. Makulu.

As mentioned earlier (p 108), trying new methods involves the farmer in other costs apart from actual expenditure. Foremost of these is risk, particularly where the experiment concerns his staple food. His main risk would be that of making a mistake in treatment. There would also be a certain risk attached to doing something different from his neighbours.

In some cases the cost to the farmer of the time spent in learning a new method would be small, since extension officials visit villages and embody instruction in the course of giving other services. However, another way of teaching is to encourage farmers to attend a short course at a training centre. Such courses are put on outside the peak seasons of agricultural activity but still represent a cost of time and effort to the farmer, particularly if he has another occupation apart from farming.

Benefits

1. Weight

One of the benefits of storing maize in the recommended way is a reduction in weight loss. A summary of dry weight losses in the relevant Mt. Makulu stores is given in Table 55. This reproduces the results obtained in Part 4, and shows the quantities of maize represented by the percentage loss. From this data a figure of net loss may be calculated to represent the additional quantity of maize that would have been available if, in all cases, storage had been by the improved method. This amount is found by applying the percentage weight loss found in maize stored in the recommended way to the quantity of maize in the other stores and then deducting the result from the loss which actually occurred. For example, the benefit, in quantitative terms, of treating the grain in store M4 would be 8 kg obtained by deducting 1.1% of 555 from 14. In the case of the maize stored in cob form the benefit used as a basis for later calculations is the mean of the net losses shown for stores C3 and C4.

Table 55

A summary of dry weight losses in selected Mt. Makulu stores

No. of store	Method of storage	Quantity put into store: Bags of grain/grain equivalent	Quantity put into store: Dry weight (kg)	Dry weight loss: Per cent	Dry weight loss: Quantity (kg)	Dry weight loss: Net*
M4	Untreated grain in Muddied store	7	555	2.6	14	8
M5	Treated grain in Muddied store	7	560	1.1	6	–
C3	Cobs with husks	4	338	13.0	44	40
C4	Cobs with husks	4	324	13.0	42	38

*Loss assumed to occur due to storage not being in the recommended way

The value put on this additional maize depends on the assumption which is made about how it would have been used if available, and in this respect the information collected during sampling visits on the prices at which maize transactions took place is used. However, these rates only apply to a select number of farmers. To allow for the fact that some transactions in grain take place outside these limits the prices of K3.00 and K5.00 per 90 kg bag have also been taken as parameters. In addition, some farmers buy roller meal instead of grain and in this case the cost would be approximately K5.35 per 100 kg bag. It has been mentioned earlier that this price is heavily subsidised and that a conservative estimate of the extent of this is 50%. It is possible that this subsidy may eventually be removed and to take cognisance of this fact meal has also been priced at 150% of K5.35 – K8.03 per bag. The results of pricing weight loss at these rates are shown in Table 56. In the case of maize currently stored in cob form the benefit would vary, depending on the price used, between K1.30 and K3.48 and in that of untreated grain between K0.27 and K0.71. If the average price at which maize purchases took place amongst the selected farmers is used the benefits would be K1.73 or K0.36.

2. Quality

The qualitative benefits of improved storage are now assessed using the same method as in Part 5. Table 34 (p 88) showed the grades of maize taken from Mt. Makulu stores and in Table 57 these are quantified and valued on the basis of Grade A maize being priced at K4.00 per bag, Grade B K3.95, Grade C K 3.85 and maize under Grade C at

Table 56

The value of quantitative benefits obtained by adopting an improved storage system

	Current method of storage: Untreated grain in muddied store		Current method of storage: Cobs with husks attached	
Price per 90/100 kg bag*	Quantitative benefit (kg)	Total value (K)	Quantitative benefit (kg)	Total value (K)
3.00G	8	0.27	39	1.30
3.91G	8	0.35	39	1.69
4.00G	8	0.36	39	1.73
5.00G	8	0.44	39	2.16
5.35 RM	8	0.48	39	2.32
8.03 RM	8	0.71	39	3.48

Notes: (1) Grain prices, G, represent the minimum and maximum rates at which this would be bought from farmers, and buying/selling rates amongst selected farmers.
(2) Roller meal, RM, representative price with and without subsidy.

* 90 kg bag of grain, 100 kg bag of roller meal

Table 57

The value of qualitative benefits obtained by adopting an improved storage system

	Current method of storage and store number							
Maze removed	Untreated grain in muddied store, M4		Treated grain in muddied store, M5		Cobs with husks attached C3		C4	
Grade	Kg	K	Kg	K	Kg	K	Kg	
A (4.00)	0	0	87	3.87	14	0.62	13	[illegible]
B (3.95)	139	6:10	213	9.34	27	1.19	15	[illegible]
C (3.85)	239	10.22	143	6.12	102	4.36	89	[illegible]
Under C (2.00)	163	3.62	111	2.47	146	3.24	159	[illegible]
Totals	541	19.94	554	21.80	289*	9.41	276*	
Value per 90 kg bag	K3.32		K3.54		K2.93		K2.80	

Notes: ( ) Rate at which grade is priced, per 90 kg.
*These figures are slightly below those that may be obtained from Table 55 due to the rounding necessitated on converti each withdrawal to its dry weight grain equivalent.

K2.00. The total value of the maize drawn from each store is: K21.80 for grain stored in the recommended manner, K19.94 for untreated grain, and K9.41 and K8.58 for the two cob stores. So that the advantage of the improved method of storage can be assessed, these values are also shown for comparison purposes on the basis of a common unit – a 90 kg bag. This may be visualised as containing maize of various grades in proportion to the amount each grade formed of the total maize removed from the store, and with each proportion being valued at its respective price. The value of a representative bag drawn from maize stored in the recommended manner and assessed in this way is K3.54. For untreated grain it is K3.32 and for cobs with husks K2.93 for C5 and K2.80 for C4. The data is now in a form that can be used in assessing benefits by putting a quality premium of K0.22 per bag on treated over untreated grain, and one of K0.67 per bag on treated grain over cobs with husks (using the mean value of K2.87 for the cob stores).

3. Other benefits of improved storage (see also P 000 and Part I).
One additional benefit already mentioned, is an increase in the nutritional value of a farmer's maize. No nutritional analysis was conducted, so that no evaluation could be attempted. In practice, this would have been difficult because nutritional content is not a factor affecting maize prices in Zambia, and therefore any artificial pricing system adopted would have possessed a considerable degree of subjective judgement. A further problem in arriving at any assessment would have been the lack of nutritional knowledge amongst the small farmers themselves, which would obviously have made obtaining their opinion on the value of nutritional gains almost impossible. A different type of benefit would be reduced infestation of crops from insects flying from the store. Although this gain might not be understood initially by a farmer it would be considerable and, since stores are also recipients of insects from the field, cumulative. If improvements were adopted and a noticeable reduction in losses occurred more farmers would probably be induced to store the SR52 variety of maize, since some of those surveyed gave its susceptibility to damage as a reason for not doing so at present. To the extent that this resulted in a greater quantity of SR52 being grown farmers could benefit from its higher yield.

Cost – benefit ratio

The costs and benefits to a small farmer of adopting the improved method of storage are shown in Table 58. It will be noticed that a range of values is given – low, medium and high – based on different assumptions being made about such matters as the relevant wage rate to use, the allowance of time for affecting

Table 58

Costs and benefits of an improved system of storage (in Kwacha)

(a) for farmers storing untreated grain in a muddied store

	Costs				Benefits		
	Low (I)	Medium (II)	High (III)		Low (IV)	Medium (V)	High (VI)
Purchase of Blue Cross	0.70	0.70	0.70	Weight	0.27	0.36	0.44
Time for application	0.08	0.10	0.16	Quality	1.54	1.54	1.54
Totals	0.78	0.80	0.86		1.81	1.90	1.98

Ratio of costs to benefits
Low – (III) to (IV) 1:2.1
Medium – (II) to (V) 1:2.4
High – (I) to (IV) 1:2.5

(b) for farmers storing cobs with husks attached

	Costs							Benefits		
		Low (I)		Medium (II)		High (III)		Low (IV)	Medium (V)	High (VI)
Shelling										
Farmer	0.20		0.30		0.56		Weight	1.30	1.73	2.16
Wife/family	–	0.20	–	0.30	0.56	1.12	Quality	2.44	2.68	2.96
Mudding (inc. obtaining materials)	1.28		1.80		3.20					
Remudding	–	1.28	0.20	2.00	0.32	3.52				
Purchase of Blue Cross	0.40		0.40		0.40					
Time for application	0.08	0.48	0.10	0.50	0.16	0.56				
Totals		1.96		2.80		5.20		3.74	4.41	5.12

Ratio of costs to benefits
Low (III) to (IV) 1:0.72
Medium (II) to (V) 1:1.6
High (I) to (VI) 1:2.6

NOTES:

1. Rates used for farmer's labour (per hour) Low K0.08, Medium K0.10, High K0.16
2. Rates used for costing quantitative benefit (per 90 kg bag) Low K3.00, Medium K4.00, High K5.00
3. Time spent on shelling between a farmer and his wife/family is allocated in the ratio of 1:4
4. Rates used for costing wife's/family labour (per hour) Low Nil, Medium Nil, High K0.04
5. Time spent on mudding (hours) Low 16 (no remudding), Medium 19 (two hours' remudding), High 22 (two hours' remudding)
6. In assessing the quantitative benefits for a farmer storing cobs with husks the rates used are (per 90 kg bag)
   - Low K0.61 (result for store C3)
   - Medium K0.67 (mean of Low and High)
   - High K0.74 (result for store C4)

improvements and the price at which to value benefits. The medium range of values is intended to represent the most likely costs and benefits within the parameters of the current storage season and the data obtained from the selected farmers. The rates used do not comprehensively cover all possibilities but only the more likely. As an example of this, no farmer was assumed to buy roller meal since this was a comparatively rare occurrence amongst those farmers visited.

For a farmer storing his maize in grain form the benefits of applying Blue Cross insecticide always exceeded the costs involved. The ratios of cost to benefits were 1:2.1, 1:2.4 and 1:2.5. It is interesting to note that the use of Blue Cross could be justified on the grounds of the improvement in the quality of a farmer's maize but not, taken by itself, on the reduction in its weight loss.

For a farmer currently storing cobs with husks attached the benefits would exceed costs except in the case where benefits are assumed to be at their lowest and costs at their maximum, or marginally, where both costs and benefits are assumed to be at their maximum. The 'low' 'medium' and 'high' ratios in this case were 1:0.72, 1:1.6 and 1:2.6. The ratios are influenced to a high degree by the assumptions made about the time taken for mudding and the rate at which it is costed. In contrast to a farmer already storing grain a ratio of more than 1.1 for the medium range of values is dependent on both weight and quality benefits being achieved. In interpreting the results it should be noted that the amount of mudding embodied in the costs will be necessary only for one year. After this all that is usually necessary is for a farmer to replace mud that has been displaced during the season.

The actual values obtained in the analysis are heavily dependent on the assumptions made (see notes to the Table) and on the assessments of physical losses made in Part 4. In this respect two points should be emphasised. Since unselected cobs were put into the simulation stores the extent of damage to the maize is likely to have been higher than would be experienced in the field (p 85), so that the actual benefit of changing to the recommended method is likely to be lower than the results in Part 4 suggest. Also, the formulation of Blue Cross insecticide applied to the shelled grain was considerably stronger than the recommended dosage (see p 90) and this may also have reduced damage to a limited extent. However, this effect is not thought to have been significant since application of the correct strength is known to be adequate for its purpose.

The social viewpoint

No assessment is provided in monetary terms since to attempt one would imply that the findings of the present study are representative of Zambia as a whole.

Costs

No subsidies are given to encourage adoption of the recommended method of storage and its main cost lies in the use of extension staff, who are very limited in number, in training farmers. A thorough evaluation of this would be difficult, involving an assessment of the time spent by officers on training farmers in storage amongst all their other work and an investigation of how many farmers had changed their method of storage due to their efforts. Included in the cost of training would have to be an allowance for transport since the availability and cost of this is an important constraint on the attention which farmers receive.

The time of extension officers is a scarce resource and it is necessary to ask whether giving training in storage techniques is its most profitable use.

Government objectives for the rural sector of the economy include improving storage and nutritional standards, but also the long term development of family farms as the basic unit of production. Another aim is provincial self sufficiency in staple items and, in order to save transport costs, this is thought particularly important for those products with a low value/weight ratio such as maize.

Improving storage is unlikely to make an appreciable contribution to provincial self sufficiency although, to a limited extent, a reduction in losses would result in a reduced demand for maize from farmers, whose own supplies would often be sufficient to meet their needs. However, this reduction would only be significant if farmers were currently suffering heavy losses and therefore making appreciable purchases. The findings of this report, suggest that this is not the case, at least, amongst the small sample of farmers visited.

Provincial self sufficiency could also be achieved by increasing maize production and sales. A thorough examination of the techniques and constraints on production was made in a recent agricultural labour productivity investigation (Universities of Nottingham and Zambia 1970–73) and it is possible that if some of the findings were put into effect they might be a better way of fulfilling Government objectives. Summarising, the opportunity cost of the time spent in attempting to improve storage cannot be assessed until alternative ways of reaching defined objectives have been examined.

Benefits

The main beneficiaries of storage improvements would be the small farmers themselves. A long term benefit to the country as a whole could result from their eating better quality food which might assist in stimulating their production. A more immediate stimulus could be the increased growing of hybrid type maize. In the survey areas there is already a trend in this direction which might be accentuated if the problem of its susceptibility to loss in store could be overcome. Further benefits might result but, on the evidence of a report covering only two small areas in which the level of losses has been found to be relatively low, they cannot be readily foreseen.

ASSUMPTIONS

It is now necessary to examine the assumptions underlying any study of storage improvements and to consider to what extent these are valid in the context of this report.

The first assumption is that the existing system of storage is sufficiently poor to need changing. Ultimately, this is a question of subjective judgement. The evidence obtained about standards of storage is too limited for any definitive conclusion to be reached, but what can be said is that the losses found amongst those farmers storing selected cobs were not of such a level as to present a case for immediate action.

Another pre-requisite to a study of the benefits of improving storage is a consideration of what objective will be achieved if innovations can be introduced and whether changing a system of storage is the best means of achieving them (p 108).

A third assumption is that, given the need, methods of storage can be changed — preferably in the not too distant future. To justify this it will be necessary to examine the role of storage in the economy, its possible importance in the social system, the storage strategy of the community and the role of any external purchasing agencies. Apart from this, it will be helpful to know if there is any dissatisfaction amongst farmers about existing methods since, where this exists, it will be easier to introduce change. One of the main factors that could motivate small farmers of the type studied would be heavy storage losses. However, there was no widespread opinion amongst those in the project areas that losses were heavy, and to this extent it is difficult to show the necessity for them to alter their methods of storage. This is borne out by the findings of the questionnaire surveys for, although many farmers realised that their maize suffered damage, few had considered making changes to their stores (p 48).

The last major assumption, and it is one made all too readily when advocating action by developing countries, is that the particular kind of improvement recommended is practical. This does not mean simply that it is suitable for its intended purpose, but also that it fits in with established customs and, where expenditure is necessary on the part of the farmer, the means to pay is within his scope. In this context the timing of payments, the factors governing the obtaining of credit, and existing patterns of expenditure will all be relevant.

Of the improvements recommended in the present study the techniques of shelling and mudding are well known to farmers so that they would experience no difficulty in applying them. The application of Blue Cross in the correct manner should also raise few problems that could not be overcome, the main danger probably being that farmers might under treat their maize to save money. It is difficult to generalise about the question of whether farmers could afford Blue Cross but, given the fact that many already use some form of insecticide on their maize it is likely that most, given sufficient incentive, would be able to buy it. However, a few farmers, growing their crops purely for subsistence purposes and engaging only in a minimal number of cash transactions, would have some difficulty.

In 1974 the supply of Blue Cross to rural areas was insufficient and it is therefore necessary to mention that, as a pre-requisite to motivating the farmer to try improvements it is essential that the materials concerned should be easily obtainable.

Finally, it is worth stressing the importance of an examination of the validity of assumptions such as those considered. If this is not made, there is a real danger that after much time, effort and resources have been spent, the improvements suggested will have no practical application.

Part 7

Conclusions and recommendations

CONCLUSIONS

In interpreting the following conclusions it should be remembered that the project was concerned with two small areas during one season only.

Causes of Loss

Virtually all the damage both to the farmers' grain and to that in the simulation stores was caused by insects (p 69). There was little evidence of mould (p 68) or rodent losses (p 68) and farmers did not consider these factors to be a problem.

Measurement and estimates of loss

Losses in dry weight were most accurately estimated using a continuous sampling technique over the season in conjunction with records of consumption. The use of the weight of a standard volume corrected for moisture content and its comparison with that at the time of commencement of storage was the best method for estimating the loss (p 78). This was refined using multiple regression techniques to reduce the variation in the estimate. The variables added were percentage damaged grains and time in store. Under normal survey conditions this refinement would be impracticable because of the lengthy and complicated analysis. If continuous assessment at monthly intervals is not possible an estimate of loss in a sample may be obtained using the formula comparing damaged and undamaged fractions, provided the level of hidden infestation and multiple infestation per grain is not high (p 80). Percentage damaged grains multiplied by $^1/_8$th gave an approximate estimate of loss for rapid field use, but it is more subject to errors than the previous methods (p 81). Analysis of single samples takes no account of the importance of consumption with time which must be used in relation to weight loss for seasonal estimates to be computed.

The weight of dust recovered, weight of 100 grains, number of insects recovered or bred out were not sufficiently well correlated with loss in weight to be of use in the estimation of loss under field conditions (p 80). The highest losses occurred in cobs stored without husks at Mt. Makulu; these were inedible seven months from harvest. Unselected cobs at Mt. Makulu lost 13% in dry weight over the storage season (p 75) compared with a loss of 2 – 6% by farmers practising some degree of selection for undamaged and tight husked cobs (p 83). Farmers with a surplus at the end of the season suffered the highest losses. There were too few untreated shelled grain stores in the field for an accurate loss assessment to be made. However, from experience at Mt. Makulu there appears to be a reduction of loss if grain is removed from the bottom of the store instead of the top, losses in the simulation stores with bottom removal being below 3%. Treatment with Blue Cross insecticide reduced losses to between 0 – 1% (p 74). Quality loss may be adequately assessed by the use of an objective grading system based on current marketing standards with the addition of the farmer's subjective judgement. Farmers lowered their acceptance standards as the season progressed and the quantity of grain in store diminished.

The evaluation of loss

Two bases were used for evaluating weight loss. One was the attribution of a value to the intended use of the maize concerned which, because of its loss had to be foregone. The other was a standard price — the average at which grain was purchased by farmers. The value of farmers' weight losses was low, up to a maximum of K3.57 per store (p 98). This partly reflects the low level of physical losses incurred during the particular storage season, but also the economic framework affecting the use of maize. Of particular importance in this respect are the practice of farmers selling their surplus maize before storage takes place and the existence of an established marketing system preventing the exploitation of shortages. Farmers' quality losses were assessed using the prices paid for different grades of maize by the NAMBoard. Except in one case these were higher than the values placed on weight losses — up to a maximum of K15.51 per store or 24% of the maximum value possible (p 100). The total loss suffered by a farmer also includes those costs which he would not have incurred, but for the expectation of damage to his stored produce.

The highest total loss per store of K20.05 was suffered by a farmer storing grain (in one store). The mean loss for those storing cobs was K5.38 (median K3.56) with a highest value of K9.06 (Table 51, p 103). With one exception quality losses suffered by farmers were greater than those suffered due to loss of weight.

Losses were also assessed from the social viewpoint. The value attributed to weight losses was based on the border price at which Zambia could have exported the maize. Quality losses and indirect costs were valued in a similar way to that used for individual farmers. The total value put on the social costs of the losses suffered by the eight farmers whose losses were evaluated was K95.05 (Table 52, p 106).

Questionnaire surveys

The questionnaire surveys were most helpful in obtaining a broad outline of farmers' current activities and of events in the recent past on which an evaluation of loss could be based.

Difficulty was experienced in the collection of accurate quantitative data, such as the usage of stored maize, and in obtaining farmers' opinions on hypothetical situations. It is possible that the use of attitude statements might improve this.

A comparison of the loss estimates obtained from the questionnaire surveys with those from the programme of sampling indicated that this approach may have some value where assessments are being made for a large number of farmers. However, it should be coupled with a sampling analysis programme which would be smaller than if assessment was solely by this means (p 60).

Cost-benefit ratio of improved storage techniques

The number of farmers who had adopted the recommended method of storage was negligible and its costs and benefits were calculated using the quantitative data obtained from the simulation stores.

Incremental costs and benefits were compared with a value being attributed to the time spent on incorporating the improvements, and the gain in weight and quality being assessed.

The 'most likely' ratio of costs to benefits where storage was currently in the form of untreated shelled grain was 1:2.4 and where storage was currently as (unselected) cobs with husks attached 1:1.6 (Table 58, p 117).

The benefit of changing to the improved method exceeded the costs except where, in the case of cobs with husks currently being stored, costs were assumed at their highest.

RECOMMENDATIONS

These recommendations are in two parts; first, in relation to the third objective of the project and, second, on the carrying out of research projects.

1. The third objective reads: 'to recommend whether a longer-term project should be undertaken over a wider area to evaluate the cost/benefit relationships of improved storage techniques to enable African countries to plan development programmes in this field.'

   There is need for further projects on that part of the work, within this project, on methodology of measuring physical losses – either in maize in other environments, or on other commodities, or both.

   However, it is not recommended that further projects, even if longer-term and covering a wider area, be undertaken with the objective of helping African countries *generally* to plan development programmes. This is because the cost/benefit results of such projects are unlikely to be transferable to other situations and environments.

   But, it is recommended that before improved storage techniques involving significant use of resources are introduced for general use in the given area, they should be submitted to cost/benefit analysis.

   This implies either that the basic data, for the area under consideration, is available or that it has to be obtained.

   The data used for this analysis should be as broadly based as possible in terms of covering the variability between seasons, of environment and farmers' practices in the given area. Data collection is demanding on resources and, because of this, and in order to assess the severity of the loss to be tackled, there should be adequate Project Identification – which might take the form of a brief pilot investigation.

   The Project Identification (or brief pilot investigation) may recommend an in-depth study to obtain the necessary background, technical and local information.

2. The following are guidelines, based partly on the experience of this project, for carrying out such studies:

   (i) An inter-disciplinary team, comprising a storage technologist and an economist, is necessary,

   (ii) the Team should arrive in the country early enough before harvest to enable it to plan effectively, to select fieldwork areas, to train and brief enumerators, and to carry out any trial runs that may be necessary,

   (iii) areas chosen for fieldwork should be as representative as possible of traditional practices, both pre-and particularly post-harvest. This will entail comprehensive discussions and study of available data, and maybe a brief survey, before selection of areas is made by touring,

   (iv) the sampling frame for investigations on both technical and economic aspects should be determined and stratified.

Information on the technical aspects of losses should be obtained by:

A. Collecting the necessary baseline data on the moisture content, damage and bulk density (bushel weight) of the commodity immediately prior to storage, and recording any procedures involving selection or treatment of the produce for storage.

B. Recording the quantity of the commodity placed in storage.

C. Recording the date on which some of the commodity is first removed from the store. Thereafter samples of the commodity should be taken at monthly intervals. The sampling method used should be pre-tested, prior to large scale use, for its acceptibility to both the investigator and the farmer.

D. Collecting information on the rate of consumption of the stored commodity over the storage period. This should be done on each sampling visit.

E. Analysing the samples to obtain estimates of loss and applying these to the consumption pattern in order to obtain an estimate of loss over the complete storage period. The weight of a standard volume of grain corrected for moisture content changes should be used to assess losses in samples when regular sampling is carried out. If this is not possible the formula method may be used to estimate losses within individual samples, but with less accuracy.

F. Setting up simulation stores, if necessary, which are under the control of the investigator and simulate the farmers' pattern of consumption. The commodity should be accurately weighed in and out of the store. Care should be taken that the grain placed in these stores is of the same quality and selected in the same way as that placed in the farmers' stores.

Information on economic aspects will be obtained:

(A) by a questionnaire survey on a 'one-off' basis, conducted with a representative sample of farmers (see (iii) above),

(B) on a regular basis from farmers from whom grain samples are taken, if this is part of the research, and

(C) from official sources.

(A) *Questionnaire survey*

This should be evolved in three stages —

(i) a basic outline should be prepared following discussions referred to in (iii) above,

(ii) a trial run, see (c) below, will be necessary,

(iii) a final revision. The questions to be asked will depend on the objective of the survey, the potential ability of the interviewees to respond and the time and staff resources available to the research team. Appendix B3 shows the final survey questionnaire evolved as being the most appropriate to the conditions encountered in the project reported.

The questionnaire should be sectionalised as follows; (some but not all of the main subject areas are shown):

General. Farmer's status, household size, measurements of wealth (eg cattle ownership, alternative employment, size of farm), credit facilities and usage of.

Cropping. Crops grown, area and disposal/storage.

Principal grain crop/s production. Varieties grown, seed source and costs, use of fertilisers and insecticides, drying and pre-storage activities.

Storage. Quantity stored, form in which stored, number and type and structure of stores, cost of stores and store materials, labour for building and maintenance, age of stores, potential life, pre-storage and in-store treatments, dates of first and last removals, frequency and quality of grain removed, site of removal from the store, usage of grain removed.

Storage losses. Cause, severity, usage of damaged grain.

Marketing. Sales of grain which is never stored, quantity, variety sold, reasons for sales, grade/price made, buyers, transportation.

Buying. Quantities bought, form (grain, meal etc), frequency, price, source, usage.

It is important to emphasise that the above are broad outlines only. Each situation may require some addition or deletion and all situations will require precise framing of the questions to be asked. However, six criteria should be observed:

(a) do not ask unnecessary questions, and try to limit the number and complexity of questions so that each interview is completed in 30 to 40 minutes maximum,

(b) as far as possible, frame the questions so that the answer is 'yes' or 'no'. Alternatively, frame them so that the answer is at any rate short and factual,

(c) have a trial run and revise or eliminate difficult questions,

(d) avoid 'sensitive' questions if possible and seek local advice as to which questions are sensitive (it is, however, surprising how many seemingly sensitive questions can be asked and will be answered if correctly phrased and properly put, ie this emphasises the importance of enumerator training),

(e) train enumerators thoroughly, work with them through their initial field operations and spot check their activities at intervals,

(f) consider the feasibility and advisability of moving enumerators between areas and strata both as a check on the individuals' performance and as a stimulus to them.

This questionnaire survey will probably be asked of a larger sample of farmers than the one from which samples of the grain are drawn for analytical purposes (assuming that the latter is part of the study involved). Nevertheless, all the latter should be asked the questionnaire survey; their actual activities, eg on grain removal, can be observed in practice and comparisons of observations and statements will provide a valuable check on farmers who are involved in making statements in the questionnaire survey only.

(B) *Economic information collected on a continuing basis from farmers*

If, as is likely, it is necessary to undertake a programme of regular sampling of farmers stored grain, the opportunity afforded for regular visits should be taken to collect regularly economic information, eg of usage patterns, quantities and prices for sales and purchases, time required for store building and maintenance work and cost of materials used.

(C) *Official sources*

Senior researchers will undertake these research activities. Aspects to be investigated will include supply and demand, development plans, marketing structures, transport costs and availability, prices etc.

It is recommended that evaluation should be made empirically based on the principle of opportunity cost. This necessitates the very careful definition of the objective of assessment and the view-point from which it is being made. A thorough investigation is needed of the factors determining the use of the produce concerned so that the true cost of a loss to the time when its existence is felt may be determined.

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Appendix A

Climate

The growing season for the stored crop studied in this report was 1972–73. This was classed as a drought year in many parts of Zambia and resulted in a reduction in the quantity of maize available for storage in 1973–74, as shown clearly in the Chalimbana area. The drought may also have reduced insect attack in the field and caused cobs to be smaller, drier and less susceptible to insect or mould damage when put into store. Losses may therefore have been a little lower than normal.

The storage season in which the project was conducted (1973–74) was the opposite with 20% more rain than normal in Chivuna and Mt Makulu and the crop going into store for the 1974–75 storage season was more susceptible and was heavily attacked by mould.

The effect of this increased rainfall on the stored crop under study was probably slight. The humidity would normally have been high enough for storage pests to develop.

At Lusaka Airport the rainfall was a little more varied than normal, higher than average in January, March and May, but less in December, February and April. Temperatures were lower than average as were those at Chivuna and Mt Makulu, possibly because of increased cloud. However they were not low enough to restrict the development of the storage pest populations.

Das (1973) discusses the effects of such conditions on growth and maturity in maize showing the decrease in yield expected when the sky is more overcast than normal. This demonstrates the problem of comparing losses between seasons as much depends on the characteristics of the crop going into store.

The following tables illustrate the differences between the mean monthly rainfall and temperature for 1973–74 and the mean over a period of years. The mean relative humidities each month are also given, although figures for the period investigated were unavailable.

Table A1
Choma: climatic data

Month	Rainfall mm 22 yr mean	Rainfall mm 1973–74	Mean Temperature °C 14 yr mean	Mean Temperature °C 1973–74	%Relative Humidity 18 yr mean
June	6	0	12.9	–	61
July	0	0	12.6	14.0	58
Aug	0	0	15.1	15.4	50
Sept	1	0	19.2	21.0	45
Oct	22	8	22.1	23.4	45
Nov	93	80	21.8	21.3	63
Dec	209	200	21.0	20.8	75
Jan	200	380	20.7	19.7	79
Feb	185	130	20.5	19.7	81
Mar	86	110	19.9	19.4	77
Apr	23	70	18.6	17.7	73
May	6	23	15.3	15.5	63
Total	831	1001			

Table A2
Lusaka International Airport: climatic data

Month	Rainfall mm 4 yr mean	Rainfall mm 1973–74	Mean Temperature °C 4 yr mean	Mean Temperature °C 1973–74	%Relative Humidity 3 yr mean
June	0	0	15.8	14.3	57
July	0	0	15.6	15.0	53
Aug	0	0	18.1	17.3	47
Sept	0	7	21.6	22.3	39
Oct	25	28	24.3	24.4	41
Nov	96	94	23.1	21.5	58
Dec	245	206	21.5	20.9	76
Jan	216	243	21.7	20.4	77
Feb	119	89	21.4	20.5	72
Mar	60	117	21.3	20.1	68
Apr	34	10	20.2	18.2	68
May	11	22	18.3	16.9	61
Total	806	816			

Table A3
Mt. Makulu: climatic data

Month	Rainfall mm 10 yr mean	Rainfall mm 1973–74	Mean Temperature °C 10 yr mean	Mean Temperature °C 1973–74	%Relative Humidity 10 yr mean
June	0	0	16.1	15.5	55
July	0	0	16.0	16.2	51
Aug	0	0	18.3	18.5	44
Sept	1	0	22.0	23.1	37
Oct	15	9	24.8	24.8	40
Nov	97	59	22.7	21.7	59
Dec	222	137	21.1	20.8	74
Jan	166	313	21.0	20.3	75
Feb	179	80	20.8	20.1	80
Mar	60	135	20.7	20.1	77
Apr	17	8	19.8	18.7	69
May	5	53	17.3	16.6	57
Total	662	794			

Appendix B

Supplementary data from questionnaire surveys and copies of survey forms

1. CHIVUNA

(a) By what method did you plant your maize?

Broadcast 0 | Rows without spacing 0

Rows with spacing 20 | Other 0

(b) What tools did you use?

Hoe 12 | Plough 15 | Planter 3

Cultivator 9 | Harrow 2

Source (a) and (b) *Intensive survey* 1972–73

(c) Did you use fertilizer or insecticide on your crops?

Intensive survey 1973–74

	No	*Fertilizer*		Insecticide
		Organic	Inorganic	
Local	3	1	2	0
Hybrid	0	1	13	1
HK	3	3	2	0

Extensive survey

	No	Fertilizer*	Insecticide
Local	8	2	0
Hybrid	4	46	1
HK	11	11	0

*No breakdown obtained

2. CHALIMBANA

(a) By what method did you plant your maize?

Broadcast 0 — Rows without spacing 7

Rows with spacing 5 — Other 0

(b) What tools did you use?

Hoe 0 — Plough 12 — Planter 0 — Other 0

Source (a) and (b) *Intensive survey* 1972–73

(c) Did you use fertilizer or insecticide on your crops last season?

Intensive survey 1973–74

	No	Fertilizer	Insecticide
Local	5(3)	1(2)	0(0)
Hybrid	2(0)	2(7)	0(1)

( ) *Intensive survey* 1972–73)

Extensive survey

	No	Fertilizer	Insecticide
Local	18	6	0
Hybrid	5	12	0

Appendix B2

ECONOMICS OF STORAGE PROJECT – QUESTIONNAIRE

Intensive survey 1972–73 storage season

Name of interviewer

Date of interview

Place of interview:

District:

Village:

Period covered

Section A – General information on farmer

1. Name
2. Village status and tribe
3. Age: 20 & under ______ 21–40 ______ 41–60 ______ over 60 ______
4. Number of wives
5. Number of children:
   (a) Permanently resident on farm
   (b) Ages of children permanently resident:
   0–7 ______ 8–14 ______ 15–18 ______
   (c) Number of children absent from farm
   (d) Total number of children
6. How many people were you feeding regularly?
7. How long have you lived on your farm?
8. Where did you live before:
   District
   Village
9. (a) Have you received any education?
   Yes ______ No ______
   (b) If yes, what education have you received?
   Primary/Form ______ Secondary/Grade ______
   Diploma ______ Other, specify ______
10. (a) Have you received any agricultural training?
    Yes ______ No ______
    (b) If yes, please specify
11. (a) Did you receive regular visits from an agricultural extension officer?
    Yes ______ No ______
    (b) If yes, how often did you receive these visits?
12. (a) Did you do any other kind of work other than farming?
    Yes ______ No ______
    (b) If yes, please specify

Section B — Crops and storage

1. What crops did you grow?

   Maize ______ Sorghum______ Millet ______ Groundnuts ______

   Peas/Beans ______ Tobacco ______ Cotton ______

   Others, specify ______________________

2. Which of your food crops did you grow in most quantity?

   Maize______ Sorghum ______ Other, specify ______

3. Were any of your crops grown mainly for the purpose of sale?

   (a) Yes ______ No ______

   (b) If yes, specify

   Maize ______ Sorghum ______ Millet ______ Groundnuts ______

   Peas/Beans ______ Tobacco ______ Cotton ______

   Others, specify ______________________

   (c) Which of these crops did you sell in greatest quantity?

4. Which crops did you store?

   Maize ______ Sorghum ______ Groundnuts ______ Millet ______

   Peas/Beans ______ Others, specify ____________

The following questions refer only to maize

5. (a) How did you decide what quantity of maize to grow?

   (b) Are there any conditions in which you would grow:

   (i) More maize

   (ii) Less maize

6. What variety of maize did you grow?

   Local ______ Hybrid ______ Hybrid (once grown) ____________

7. Has the quantity of maize you have grown changed in recent seasons?

	No	More	Less
Local	____	____	____
Hybrid	____	____	____

8. Do you intent to change the quantity of maize you are growing?

	No	More	Less
Local	____	____	____
Hybrid	____	____	____

9. (a) By what method did you plant your maize?

   Broadcast ____________ Rows without spacing ____________

   Rows with spacing ________ Other ____________

   (b) What tool(s) did you use?

   Hoe ______ Plough ______ Planter______ Other ________

10. Did you use fertilizer or insecticide on your crops last season?

	No	Fertilizer	Insecticide
Local	___	________	________
Hybrid	___	________	________

11. What was the approximate date of harvest?

12. What was the approximate date of storage?

13. Which varieties of maize did you store?

Local ________ Hybrid ___________

14. How did you dry your maize?

Local

Hybrid

15. (a) Did you store your maize in the form of cobs or as shelled grain?

	Cobs (with husks)	Cobs (without husks)	Shelled grain
Local	________	________	________
Hybrid	________	________	________

(b) If shelled, how did you shell it?

By hand _______ Simple sheller ________ Other _______

16. What quantity of maize did you put into store last season?

	Cobs (with husks)	Cobs (without husks)	Shelled grain
Local	________	________	________
Hybrid	________	________	________

17. (a) How do you decide how much maize to store?

(b) Are there any conditions in which you would store:

(i) More maize

(ii) Less maize

18. (a) did you keep any maize for seed?

Yes ______ No _________

(b) If yes, (i) What variety did you store?

(ii) How did you store it?

(iii) How much did you store?

19. (a) Did you buy any maize for seed?

Yes _______ No _______

(b) If yes, (i) What variety did you buy?

(ii) From where did you obtain it?

(iii) What price did you pay?

20. (a) Did you sell any maize for seed?

Yes _______ No ________

(b) If yes, (i) What variety did you sell?

(ii) To whom did you sell it?

(iii) What price did you receive?

Section C – Storage facilities

1. How many stores did you have last season?

2. Of what were these made?

No. Materials.

3. (a) From where were these materials obtained?

(b) What were their prices?

4. (a) How old are your stores?

(b) For how many more seasons do you expect to use them?

5. (a) Did you spend any time in repairing your stores?

Yes ______ No ______

(b) If yes what repairs did you do?

6. (a) Did you do anything else to your store before filling it?

Yes ______ No ______

(b) If yes, specify.

7. (a) Did you treat the maize going into store?

Yes ______ No ______

(b) If yes (i) With what?

(ii) At what rate?

8. (a) Did you give it any further treatments?

Yes ______ No ______

(b) If yes, what treatments did you give?

9. (a) Have you ever considered changing your method(s) of storage?

Yes ______ No ______

(b) If yes, what changes have you considered?

Section D — Usage of stored maize

1. How often did you take maize out of your store?

Local ______ Hybrid ______

2. (a) Did you take out a similar quantity each time?

	Yes	No
Local	____	____
Hybrid	____	____

(b) If yes, what quantity did you usually take out?

Local ______ Hybrid ______

3. How did you take your maize from the store?

Top ______ Side door ______ Other ______

4. (a) For what purposes did you use your maize?

	Local	Hybrid		Local	Hybrid
Food	______	______	Gifts	______	______
Feeding dogs	______	______	To sell	______	______
Feeding other animals	______	______	Barter	______	______
Seed	______	______	Repayment of loans	______	______
Wages	______	______	Beermaking	______	______

Other purposes: Local

Hybrid

(b) Give an estimate of the proportion of your maize that was used in each of these ways during last season? (Rank if proportions not known)

	Local	Hybrid		Local	Hybrid
Food	______	______	Gifts	______	______
Feeding dogs	______	______	To sell	______	______
Feeding other animals	______	______	Barter	______	______
Seed	______	______	Repayment of loans	______	______
Wages	______	______	Beermaking	______	______

Other uses: Local

Hybrid

5. If you have a bad maize crop which of your uses of maize shows the greatest decrease?

6. (a) When you have a good maize crop which of your uses of maize shows the greatest increase?

(b) Do you try to keep some in case next years harvest is bad?

Yes ______ No ______

(c) (i) Is this maize sometimes mixed in store with that from the next harvest?

Yes ______ No ______

(ii) If yes, was any of your maize in store mixed with that from the previous season?

Yes ______ No ______

Section E – Losses

1. (a) Did the maize which you stored show any signs of damage?

Yes ______ No ______

(b) If yes were some varieties of maize more affected than others?

2. What do you think caused this damage?

Insects ______ Mould ______ Rats ______

Other factors ____________

3. At what time of year did most of this damage occur?

4. What proportion of your crop in store was affected?

(i) In total

(ii) By variety of maize

5. What did you do with your damaged maize?

6. How much maize did you throw away?

(i) In total

(ii) By variety of maize

7. How much of your maize stored for seed did you throw away?

8. If your maize suffered less damage would this alter the amount that you:

			No	More	Less
(a)	Grow:	Local	______	______	______
		Hybrid	______	______	______
(b)	Store:	Local	______	______	______
		Hybrid	______	______	______

9. How much extra maize do you think you would have had if it had not been damaged in store?

Section F — Marketing

1. What varieties of maize did you sell?
2. In what form did you sell it?
   Cob ______ shelled ______
3. In what months did you sell your maize?
4. What reasons did you have for selling at this time? (Rank if possible)
5. What grades of maize did you sell?
   A ______ B ______ C ______ Other ______

6. (a) What quantity of maize did you sell?
   Total:
   Grade: A ______ B ______ C ______ Other ______

   (b) What proportion of your sales were made before you stored your crop?

7. (a) What prices did you receive?
   (b) (i) Did these remain the same throughout the season?
   Yes ______ No ______
   (ii) If no, details

8. (a) To whom did you sell your maize?
   NAMBoard ______ Local trader ______
   Other, specify ________
   (b) What quantities did you sell to each?
   NAMBoard ______ Local trader ______
   Other ______
   (c) If any sold to NAMBoard, to where was it delivered?
   Line of rail ______ Elsewhere, specify ______

9. By what method did you transport your maize to market?

10. (a) Did you buy any maize last season?
   Yes ______ No ______
   (b) If yes, for what purpose?
   (i) What quantity?
   (ii) What variety?
   Local _______ Hybrid ______
   (iii) From where did you obtain it?
   (iv) When did you buy it?
   (v) What price did you pay?

Section G — Credit

1. (a) Did you obtain any credit to assist in running your farm?
   Yes ______ No ______
   (b) If yes, for what purpose?
   (c) At what period of the year?
2. From where did you obtain it?
3. How much were you charged?
4. In what form did you repay your loan?

STORE RECORD SHEET (attached to questionnaire)

Code No.

Date:

Structure and materials:

Age:

Height of platform above ground:

Height of container:

Circumference of store:

(Diameter of store):

(Length and width, if applicable):

(Volume of store):

Maize variety:

Shelled: Cob:

Treatment (if any):

(Approx. maximum storage capacity):

Height of maize in store:

(Approx. volume of maize in store):

(Approx. wt. of maize in store):

Distance to nearest maize store:

Distance to nearest growing maize crop:

Store cleaned before filling: Yes / No

OBSERVATIONS (attach photograph)

Appendix B3

ECONOMICS OF STORAGE PROJECT – QUESTIONNAIRE

Intensive survey 1973–74 storage season

Name of interviewer

Date of interview

Place of interview:

District:

Village:

Period covered

Harvest 1973/Storage Season 1973/74

Section A – General Information

1. Name of farmer
2. (a) How many people have you been feeding regularly?
   (b) Apart from yourself, who were these people?
   Wives ______ Children ______ Relatives ______
   Relatives Children ______ Other people (specify) ______
3. (a) What types of food do you and your family eat?
   (i) Often
   (ii) Occasionally
   (b) Do you eat the same types of food when your stored maize is finished?
   Yes ______ No ______
   If no, details:
4. (a) Have you attended any agricultural training courses during the last year?
   Yes ______ No ______
   (b) If yes, details:
5. (a) Did you do any other kind of work other than farming?
   Yes ______ No ______
   (b) If yes, details:
6. (a) Did you keep any cattle?
   Yes ______ No ______
   (b) If yes
   (i) How many
   (ii) For what purposes did you use them?
   Food for family (Meat/Milk) ______ Sale ______
   Bartering ______ Other purposes (specify) ______

Section B – Crops and storage

1. What crops did you grow?
   Maize ______ Sorghum ______ Millet ______ Groundnuts ______
   Peas/Beans ______ Tobacco ______ Cotton ______
   Others, specify: ______________________________
2. Which of your food crops did you grow in most quantity?
   Maize ______ Sorghum ______ Other, specify ______

3. Which crops did you store?

Maize ______ Sorghum ______ Groundnuts ______ Millet ______

Peas/Beans ______ Others, specify ______

The following questions refer only to maize

4. What variety of maize did you grow?

Local ______ Hybrid ______ Hybrid (once grown) ______

Hickory King ______

5. (a) From where did you obtain the seed?

	Bought	Taken from store
Local	______	______
Hybrid	______	______
HK	______	______

(b) EITHER

If bought

(i) From whom did you buy it?

NAMBoard ______ Other farmers ______

Elsewhere ______

(ii) What quantity did you buy?

(iii) What price did you pay?

OR

If taken from store:

(i) Did you store your seed separately?

Yes ______ No ______

(ii) If yes, what quantity did you store?

6. Did you use fertilizer or insecticide on your crops last season?

	No	Fertilizer	Insecticide
Local	______	______	______
Hybrid	______	______	______
HK	______	______	______

7. What was the approximate date of harvest?

8. What was the approximate date of storage?

9. Which varieties of maize did you store?

Local ______ Hybrid ______ HK ______

10. How did you dry your maize?

Local

Hybrid

HK

11. (a) Did you store your maize in the form of cobs or as shelled grain?

	Cobs (with husks)	Shelled grain
Local	______	______
Hybrid	______	______
HK	______	______

(b) If shelled, how did you shell it?

By hand ______ Simple sheller ______ Other ______

12. What quantity of maize did you put into store last season?

	Cobs (with husks)	Shelled grain
Local	______	______
Hybrid	______	______
HK	______	______

Section C – Storage facilities

1. How many stores did you have last season?
2. Of what were these stores made?

No. Materials and Structure

3.(a) From where were these materials obtained?

Bush ______ Bought ______ Elsewhere ______

(b) If bought, what was their quantity and price?

4.(a) How long did it take you to obtain the materials which you collected from the bush?

(i) In days ______ (ii) In hours ______

(b) How did you carry these materials back to your farm?

(c) How long did it take you to build your store with these materials?

(i) In days ______ (ii) In hours ______

(d) (if appropriate) How long did it take to mud your store?

(i) In days ______ (ii) In hours ______

5.(a) In which month did you build your store(s)?

(b) What other jobs do you normally do on your farm at that time of year?

6.(a) How old are your stores?

(b) For how many more seasons do you expect to use them?

7.(a) Did you spend any time in repairing your stores?

Yes ______ No ______

(b) If yes, what repairs did you do and how long did they take?

8.(a) Did you do anything else to your store before filling it?

Yes ______ No ______

(b) If yes, specify

9.(a) Did you treat the maize going into store?

Yes ______ No ______

(b) If Yes (i) with what?

(ii) at what rate?

10.(a) Did you give it any further treatments?

Yes ______ No ______

(b) If yes, what treatment did you give?

Section D – Usage of stored maize

1. (a) When did you start using maize from your store(s)?

(b) By when was the maize in your store(s) finished?

2. (a) How often did you take maize out of your store(s)?

Local ______ Hybrid ______ HK ______

(b) (To be asked only if farmer has more than one store)

(i) Did you take out all the maize from one of your stores before starting on another?

Yes ______ No ______

(ii) If no, in what order did you use the maize from your stores?

3.(a) Did you take out a similar quantity of maize from your store(s) each time?

	Yes	No
Local	______	______
Hybrid	______	______
HK	______	______

(b) If yes, what quantity did you usually take out?

Total ______ From each store ______

4. How did you take your maize from the store(s)?

Top (lifting roof) ______ Side door (near top) ______

Side door (near bottom) ______ Elsewhere ______

5. For what purposes did you use the maize which you stored and what quantity did you use for each purpose? (Number of bags/tins)

	Loc.	Hyb.	HK		Loc.	Hyb.	HK
Beermaking	____	____	____	Seed	____	____	____
Food	____	____	____	Gifts	____	____	____
Feeding dogs	____	____	____	Barter	____	____	____
Feeding other animals	____	____	____	Wages	____	____	____
To sell	____	____	____	Repayment of loans	____	____	____

Other purposes: Local

Hybrid

HK

Section E — Losses

1.(a) Did the maize which you stored show any signs of damage?

Yes ______ No ______

(b) If yes, were some varieties of maize more affected than others?

2. At what time of year did most of this damage occur?

3. What quantity of your stored maize was damaged?

(i) In total

(ii) By variety of maize

4. What did you do with your damaged maize?

5. (To be asked only if farmer stores maize for seed separately)

(a) Did the maize which you stored for seed show any signs of damage?

Yes ______ No ______

(b) If yes, what quantity was damaged?

Section F — Marketing

1.(a) Did you sell any maize before you stored your crop?

Yes ______ No ______

(b) If yes, of what variety?

Local ______ Hybrid ______ HK ______

2. In what months did you sell your maize?

3. What reasons did you have for selling at this time? (Rank if possible)

4.(a) What quantity of maize did you sell?

(b) What grade was this maize?

A ______ B ______ C ______ Other ______

(c) What price did you receive?

5.(a) To whom did you sell this maize?

NAMBoard ______ Local trader ______ Other farmers ______

Friends ______ Others (specify) ______

(b) If any sold to NAMBoard, to where was it delivered?

Line of rail ______ Rural depot ______

6. By what method did you transport your maize to market?

Scotch cart ______ Lorry ______ Other, specify ______

7. (To be put only to those farmers who sold maize from their stores)

(a) In what month(s) did you sell maize from your store?

(b) To whom did you sell it?

NAMBoard ______ Local trader ______ Other farmers ______

Friends ______ Other (specify) ______

(c) What price did you receive?

(d) (i) Did this price remain the same throughout the season?

Yes ______ No ______

(ii) If no, please give details:

8. Did you buy any maize last season?

Yes ______ No ______

If yes:—

9. In what form did you buy it?

Shelled grain (variety) ______ Maize meal ______ Other ______

10. Did you make more than one purchase?

Yes ______ No ______

11. When did you make this purchase (or purchases)?

12. What quantity did you buy?

(i) In Total ______

(ii) On each occasion ______

13. From where did you obtain the maize which you bought?

14. What price did you pay?

15. Did this remain the same throughout the season?

Yes ______ No ______

Details if no:

16. Was the maize which you bought used entirely for food for your family?

Yes ______ No ______

Details if no:

Section G — Credit

1.(a) Did you obtain any credit to assist in running your farm?

Yes ________ No ________

(b) If yes, for what purpose?

(c) What quantity did you obtain?

2. From where did you obtain it?

3. What rate of interest were you charged?

Appendix B4

ECONOMICS OF STORAGE PROJECT – REDUCED QUESTIONNAIRE

Extensive survey 1973–74 storage season

Name of interviewer

Date of interview

Place of interview:

District:

Village:

Period covered: 1973 Harvest (73/74 storage season)

Section A – General information on farmer

1. Name:
2. Age: 20 & under. ______ 21–40 ______ 41–60 ______ over 60. ______
3. Number of wives.
4. Number of children:
   (a) Permanently resident on farm.
   (b) Ages of children permanently resident:
   0–7 ______ 8–14 ______ 15–18 ______
5. How many people were you feeding regularly?
6. How long have you lived on your farm?
7. Where did you live before:
   District __________
8. (a) Have you received any education?
   Yes ______ No ______
   (b) If yes, what education have you received?
   Primary/Grade ______ Secondary/Form ______
   Diploma ______ Other, specify ______
9. (a) Did you do any other kind of work other than farming?
   Yes ______ No ______
   (b) If yes, please specify

Section B – Crops and storage

1. Which crops do you grow:
   Maize ______ Sorghum ______ Millet ______ Groundnuts ______
   Peas/beans ______ Tobacco ______ Cotton ______
   Others, specify ______
2. Which crops did you sell:
   Maize ______ Sorghum ______ Millet ______ Groundnuts ______
   Peas/beans ______ Tobacco ______ Cotton ______
   Others, specify ______

3. Which crops did you store:
   Maize ______ Sorghum ______ Groundnuts ______ Millet ______
   Peas/beans ______ Others, specify ______

The following questions refer only to maize

4. What variety of maize did you grow:
   Local ______ Hybrid ______ Hybrid (once grown) ______
   Hickory King ______
5. Did you use fertilizer or insecticide on your crops:

	No	Fertilizer	Insecticide
Local	______	______	______
Hybrid	______	______	______
HK	______	______	______

6. What was the approximate date of storage:
7. Which varieties of maize did you store:
   Local ______ Hybrid ______ HK ______

8.(a) Did you store your maize in the form of cobs or as shelled grain:

	Cobs (with husks)	Cobs (without husks)	Shelled grain
Local	______	______	______
Hybrid	______	______	______
HK	______	______	______

(b) If shelled, how did you shell it:
By hand ______ Simple sheller ______ Other ______

9. What quantity of maize did you put into store last season:

	Cobs (with husks)	Cobs (without husks)	Shelled grain
Local	______	______	______
Hybrid	______	______	______
HK	______	______	______

Section C — Storage facilities

1. How many stores did you have last season:
2. Of what were these made:
3. How old are your stores:

(b) For how many more seasons do you expect to use them:

4.(a) Did you spend any time in repairing your stores:
Yes ______ No ______

(b) If yes, what repairs did you do and how long did they take:

5.(a) Did you treat the maize going into store:
Yes ______ No ______

(b) If yes, with what:

Section D — Usage of stored maize

1. Did you remove maize from your store at regular intervals:

   Yes ______ No ______

2. How did you remove your maize from the store:

   Top ______ Side door (near top) ______ Side door (near base) ______ Other ______

3. For what purposes did you use your stored maize (No. of bags)

	Loc	Hyb	HK		Loc	Hyb	HK
Beermaking	______	______	______	Seed	______	______	______
Food	______	______	______	Gifts	______	______	______
Feeding dogs	______	______	______	Barter	______	______	______
Feeding other animals	______	______	______	Wages	______	______	______
Sale	______	______	______	Repayment of loans	______	______	______

   Other purposes: Local

   Hybrid

   HK

Section E — Losses

1.(a) Did the maize you stored show any signs of damage:

   Yes ______ No ______

   (b) If yes, were some varieties more affected than others:

2. What do you think caused this damage:

   Insects ______ Mould ______ Rats ______

   Other factors ______

3. At what time of year did most of the damage occur:

4. What quantity of your stored maize was damaged:

   (a) In total:

   (b) By variety:

5. What did you do with your damaged maize:

Section F — Marketing

1. Did you sell any maize:

   No ____ Local ____ Hybrid ____ HK ____

2. What quantities of maize did you sell in the following grades:

   A ____ B ____ C ____ Other ____

3. How much did you sell before you stored your crop:

4. What prices did you receive:

5.(a) To whom did you sell your maize:

   NAMBoard ______ Local trader ______

   Other specify ______

   (b) What quantities did you sell to each:

   NAMBoard ______ Local trader ______

   Other ______

(c) If any sold to NAMBoard, to where was it delivered:

Line of rail ______ Elsewhere ______

6. Did you buy any maize or maize seed last season:

Yes ______ No ______

(b) If yes, what quantity:

(c) What price did you pay:

Section G – Credit

1.(a) Did you obtain any credit to assist in running your farm:

Yes ______ No ______

(b) If yes, what amount did you obtain:

2. How much were you charged:

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