GRAIN STORAGE IN THE NORTHERN COMMUNAL AREAS OF NAMIBIA

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October 1997

Consultancy report to the Namibian Agronomic Board

Funded by the Ministry of Agriculture, Water and Rural Development (MAWRD), Directorate of Planning

CONTENTS

Page

Acknowledgements iii
Terms and abbreviations iii
Assumed bulk density of grain iii
Assumed rate of exchange iii

Summary 1
1. Introduction 5
2. The need for new or improved on and off-farm storage 7
    2.1 Production and self-sufficiency in cereals 7
    2.2 Storage needs in Caprivi 7
        2.2.1 Maize 7
        2.2.2 Mahangu and sorghum 9
    2.3 Storage needs in Kavango 10
        2.3.1 Mahangu 10
        2.3.2 Sorghum and maize 14
    2.4 Storage needs in North-Central Regions 14
        2.4.1 Mahangu 14
        2.4.2 Sorghum 17
        2.4.3 Pulses 17
    2.5 The need for Strategic Grain Reserves 18

3. Issues to be considered in designing storage solutions 21
    3.1 Introduction 21
    3.2 On-farm versus off-farm storage 21
    3.3 The case for subsidised storage 22
    3.4 The case for bulk storage 22
    3.5 Open storage versus warehouses 24
    3.6 Co-operatives 26
    3.7 The potential role of NDC in grain storage operations 28

4. Proposed storage solutions 30
    4.1 Introduction 30
    4.2 Improving storage of flood-plain maize in Caprivi 30
    4.3 Improving on-farm storage of mahangu and sorghum 33
    4.4 Emergency off-farm storage of mahangu in Kavango 37
    4.5 Handling period surges of mahangu supplies 39

5. The prospective impact of a future SADC free market on the recommended options 40

References 41

Appendices

1.	Terms of Reference and record of Steering Committee meeting of 16 September 1997	42
2.	List of persons met	50
3.	On-farm storage of maize by flood-plain farmers in Caprivi Region	52
4.	The marketing of commercial mahangu production in Namibia	53
5.	Synopsis of findings on farmer-controlled enterprises	56
6.	Notes on maintenance, operation, management of storage stuctures	57
7.	Points to take into account when constructing a grain storage warehouse	59
8.	Notes on open storage on poles	66

ACKNOWLEDGEMENTS

The authors wish to thank all those who contributed their time and knowledge in the development of this report, including many farmers in the NCA Regions. Particular thanks are due to Arne Larsen for organising a meeting of relevant parties in Oshakati and helping us throughout our visit to the North-Central Regions; Mr Iipinge and Mr Shatona (MMIU), Mr Liseho (NAB, Caprivi), Mr Sibolila (MAWRD, Caprivi), Ms Matsaert and Mr Makundu (KSFR/E, Mashare), Mr Likoro (NDC), Mr Immanuel, Mr Weyulu, Mr Amukoto and Ms Moses (MAWRD, North-Central Regions), for their help in arranging meetings and accompanying us on visits.

TERMS AND ABBREVIATIONS

dunnage	pallets or other material placed under maize stacks to prevent direct contact with the floor of a warehouse
kg	kilogramme
ha	hectare
lata	a tin, standard market measure for the mahangu (about 16 kg) - from Portuguese
N$	Namibian dollar
CBS	Central Statistics Bureau
CRIAA	Centre for Information and Action in Africa
FCE	Farmer-Controlled Enterprise
FSP	Farmer Support Programme
KFSR/E	Kavango Farming Systems Research and Extension Project
LFCU	Likwama Farmers' Co-operative Union
MAWRD	Ministry of Agriculture, Water and Rural Development
MMIU	Mahangu Marketing Research Unit
NCA	Northern Communal Areas
NDC	Namibia Development Corporation
NRC	Namibia Resource Consultants
NAB	Namibia Agronomic Board
NNFC	Northern Namibia Farmers' Co-operative
NOLIDEP	Northern Regions Livestock Development Project
RDSD	Rural Development Support Programme
SACU	South African Customs Union

ASSUMED BULK DENSITY OF GRAIN

Maize	1.6 cubic metres per tonne
Sorghum	1.4 cubic metres per tonne
Mahangu	1.2 cubic metres per tonne

ASSUMED RATE OF EXCHANGE

US$ 1 = N$4.7 = Rand 4.7

SUMMARY

This consultancy was commissioned by the Namibian Agronomic Board (NAB) with the objective of making recommendations on the appropriate types, ownership, management and capacities of on and off-farm storage of mahangu, maize and sorghum in the Northern Communal Areas (NCA), and to assess the need for holding strategic grain reserves.

With regard to **mahangu**, the main needs are as follows:

- In the North-Central Regions, there is an overwhelming need for improved on-farm storage to prevent attack by the moth *Corcyra cephalonica*, which may be causing physical losses in excess of 10% by weight, depending on how long farmers store the grain. Given the high prices of storage baskets made from Mopane trees, there is also a need for cheaper on-farm storage structures. Various possible storage improvements are discussed including lining baskets with polythene, and new structures such as galvanised iron, fibre-glass or plastic storage bins. A programme of trials is proposed, followed by promotion of the most viable technologies. The State and possibly NGOs should provide services in the area of R&D, training and extension, quality control, monitoring adoption and trouble shooting, while inputs and structures should be distributed by the private sector though regular commercial channels.
- In Kavango, emergency off-farm storage in roadside locations is needed to store the mahangu produced by mechanised FSP producers and Agribank borrowers in the 1997 harvest. This is to protect the grain from rain and infestation in the field, and to facilitate marketing at the best possible price. Grain should first be stored in available NDC warehouses, and where these are not available the most viable option is probably to store in the open on poles. The volume of storage required is estimated at 4,000 tonnes. It is suggested that NDC carries out the storage, given its involvement in supporting these farmers and interest in securing repayment of loans.
- Given that the financial viability of mechanised and high-input mahangu production has not been established, no long-term storage arrangements or permanent storage structures are proposed for these groups of farmers. Notwithstanding this, in both North-Central and Kavango Regions, temporary storage arrangements will periodically be needed following successive bumper crops. We estimate that this will happen at least once (and at most twice) every 10 years, with the maximum storage requirement being about 10,000 tonnes. There are likely to be smaller surplus conditions about two years out of ten, calling for off-farm storage capacity of no more than 2,500 tonnes. The capacity should be provided by private sector players, including farmers' groups and co-operatives, specialised storage operators, and buyers interested in the procurement of mahangu for processing. Training is needed to ensure that the necessary technical capability is available as and when needed to store mahangu successfully either in the open air or in warehouses. Emergency funding may occasionally be needed for the acquisition of poles and tarpaulins and these may be loaned to the relevant organisations.

The authors also examined the commercial marketing of mahangu, given that this could have a role in absorbing the periodic mahangu surpluses referred to above, while more significantly, satisfying strong consumer preferences for mahangu over maize meal. NDC has expended considerable efforts in this area since 1993, but the activity has left unanswered important questions about the potential scale and other features of the market for mahangu products.

Local processing is already being developed in the NCA, but to fully exploit market potential - particularly in Southern Namibia - it will be necessary to involve companies skilled in the development and marketing of fast-moving consumer goods (FMCGs), and capable of keeping mahangu meal on grocery shelves throughout the year. However FMCG marketers are only likely to get involved if there are prospects of reasonably stable raw material supplies, and this depends on finding other countries from which mahangu can be imported when Nambia is in short supply. At the same time Government will need to give assurances about not intervening in the market (for drought relief or other purpuses) as this could upset the supply situation.

With regard to maize, particular attention was paid to the needs of **flood-plain producers in Caprivi**, and findings were as follows:

- On-farm storage - grain should be threshed as early as possible and stored in bags on raised platforms with ratguards, under protective shelters. Insecticide should be used to protect bagged grain.
- Off-farm storage - grain should be evacuated to "Assembly Depots" which may be either centralised in Katima Mulilo or decentralised at locations adjacent to the flood-plain. Open storage on poles should be used except where suitable warehouses can be found. The total quantity stored will be very variable, depending on the harvest, but the minimum requirement is estimated at 1,000 tonnes. Farmers should be encouraged to form local groups to organise the assembly of grain, while they should probably employ specialist agencies to carry out storage and marketing on a commission basis. Before any steps are taken, there should be a thorough participatory planning exercise, involving needs assessment and a feasibility study.

Sorghum is produced in relatively small quantities, and the need for off-farm storage is negligible. However, the threshed grain, particularly of red sorghum, is more susceptible to storage pests than is mahangu, and this is restricting the amount of grain that farmers can safely harvest and store. With a view to avoiding unnecessary use of insecticides, it is suggested that farmers be advised to store sorghum unthreshed, as this will allow safe storage for at least one year.

There authors can find no case for Government establishing **a strategic grain reserve**, given that:

- many farmers already hold their own strategic stocks - two years' mahangu requirements - for food security purposes;
- Nambia enjoys easy access to world grain markets;
- the costs of holding reserves is high (upwards of 20% of grain cost per annum), and;
- the management of such reserves tends to become dominated by short-term political considerations, resulting in unnecessary financial losses and damage to local grain markets.

Certain key principles and concepts underly the above proposals, i.e.:

- The fundamental importance of on-farm storage in assuring food security at household and village level
- The need for local self-reliance and co-operation in an increasingly changing environment
- The need to develop specialist service providers, e.g. in the area of storage and food marketing
- The role of the State and NGOs in facilitating local initiative

Key findings concerning on-farm storage are summarised in Table 1.

TABLE 1: SUMMARY OF KEY FINDINGS

Place	Category of farmer*	Crop	Disposal	Period	Site	Store type	Pest control required
Caprivi	Flood-plain and rain-fed	Maize	Household	< 1 year	At house	Cobs with husks in basket	None needed
	Flood-plain	Maize	Commercial sales, where possible taking advantage of early harvesting	To allow drying, threshing, bagging and marketing	On-farm: bagged. Off-farm: at Assembly Depots	Bag store	On-farm: Contact insectide, raised platforms with ratguards & keep dry. Off-farm: Clean bags and store, dunnage, good stacking, regular inspections, fumigation with phosphine at 1 gm / m3 every 4 month
Kavango	C3	Mahangu	Household	< 1 year	On-farm	Bin	None
	C2 + 1	Mahangu	Household	1 year	On-farm	Bin	None
	C2 + 1	Mahangu	Household	2 years	On-farm	Bin or bags	Plastic liners, pesticides or new structures
	Mechanised + C1	Mahangu	Commercial sales (emergency operation for 1997)	< 1 year	Off-farm Assembly Depot	Bag store	Clean bags, clean store, dunnage, good stacking, regular inspections
North-Central Regions	C3	Mahangu	Household	< 1 year	At house	Basket	Clean and re-mud interior of basket before filling with new crop
	C1 + 2	Mahangu	Household	2 years	At house	Basket	Experiment with physical methods for excluding *Corcyra cephalonica*
	C1 + 2 + 3	Beans and cowpeas	Household	1 year	At house	Bags and drums	Use wood ash at 1 part ash to 20 parts grain; experiment with soaking and drying legumes
	C1 + 2 + 3	Sorghum	Household brewing	1 year	At house	Bags, bins and baskets	Store on the head; white varieties not susceptible to insect pests
	C1 + 2	Mahangu	Commercial sales (occasional)	< 1 year	Off-farm Assembly Dep.	Bag store	Clean bags and store, dunnage, good stacking, regular inspections

* See Table 4 for definition of categories of farmer ** dunnage = pallets or other material placed under maize stacks to prevent direct contact with the floor of a warehouse

1. INTRODUCTION

This consultancy was commissioned by the Namibian Agronomic Board (NAB), with funds from the Ministry of Agriculture, Water and Rural Development (MAWRD), and carried out in September and October 1997. The objectives were to make recommendations on the appropriate types, ownership, management and capacities of on and off-farm grain storage of mahangu, maize and sorghum in the Northern Communal Areas (NCA), and to assess the need for holding strategic grain reserves. Terms of reference are as shown in Appendix 1, as well as amendments agreed with the Steering Committee at a meeting on September 16.

The consultancy was carried out by an agricultural marketing economist and a grain storage specialist, who visited Kavango, Caprivi and the North-Central Regions in the days 5 - 17 October, collecting information from institutional and trade sources and through a series of farm visits - see Appendix 2 for list of persons met. Limited time was available for the visit to Caprivi, and at the client's request, particular attention was focused on the storage needs of flood-plain maize producers.

The terms of reference contain eleven "detailed tasks". To address these in a logical sequence, we have structured the report as follows. Section 2 discusses the needs for new and improved storage, on or off-farm, and at the level of strategic grain reserves. Section 3 discusses key issues in the design of solutions addressing these needs. Section 4 is specific in recommending how these needs should be addressed. Section 5 discusses impact of a SADC free market on our recommended options.

The terms of reference do not ask for recommendations concerning the marketing of cereals. However to provide recommendations about off-farm storage, one must first ask for what purpose one is storing. This subject has been investigated by Namibia Resource Consultants (NRC) as part of their study of the Mahangu Market Intelligence Unit (MMIU); we have kept close contact with the NRC study, and given the importance of the subject in deciding on storage policy, have ourselves made some enquiries in the area. Appendix 4 provides our own observations on the marketing of commercial mahangu production.

TABLE 2: NAMIBIA COARSE GRAIN PRODUCTION

Region and Type of Cereal	1991/92 Production Season			1992/93 Production Season			1993/94 Production Season			1994/95 Production Season			1995/96 Production Season			Forecast 1996/97 Production Season		
	`000 ha	kg / ha	`000 mt	`000 ha	kg / ha	`000 mt	`000 ha	kg / ha	`000 mt	`000 ha	kg / ha	`000 mt	`000 ha	kg / ha	`000 mt	`000 ha	kg / ha	`000 mt
North/Central Regions *																		
Ohangwena; Millet/Sorghum										85.0	175	14.9	89.0	235	20.9	89.7	350	31.4
Omusati; Millet/Sorghum										90.0	90	8.1	72.0	250	18.0	91.8	350	32.1
Oshana; Millet/Sorghum										35.0	120	4.2	35.0	185	6.5	39.0	330	12.9
Oshikoto; Millet/Sorghum										65.0	100	6.5	65.0	100	6.5	66.0	380	25.1
Sub Total	150.0	100	15.0	143.0	240	34.3	272.0	200	54.4	275.0		33.7	261.0		51.9	286.5		101.5
Kavango																		
Maize (Rainfed)	2.5	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.3	1910	0.6	0.5	2300	1.3
Maize NDC (Irrigated)	0.5	6500	3.2	0.5	5500	2.9	0.6	3500	2.0	0.4	6675	2.5	0.5	5450	2.6	0.6	5300	3.2
Millet/Sorghum NDC/FSP	0.0	0	0.0	0.0	0	0.0	4.4	685	3.0	3.0	685	2.0	5.6	770	4.3	4.2	900	3.8
Millet/Sorghum; subs.farmers	12.3	100	1.2	17.0	260	4.4	22.2	420	9.3	11.8	210	2.5	19.8	250	4.9	22.0	365	8.0
Sub Total	15.3		4.4	17.5		7.3	27.2		14.4	15.1		7.0	26.1		12.4	27.3		16.3
Caprivi																		
Maize	13.0	30	0.4	14.8	590	8.7	14.0	230	3.2	9.0	175	1.6	12.5	400	5.0	16.2	665	10.8
Millet / Sorghum	14.3	70	1.0	11.2	445	5.0	12.1	200	2.4	8.6	295	2.5	10.6	320	3.4	9.0	420	3.8
Sub Total	27.3		1.4	26.0		13.7	26.1		5.6	17.6		4.1	23.1		8.4	25.2		14.6
Commercial Sector																		
Maize (Rainfed)	22.6	230	5.2	14.0	970	13.5	17.3	1990	34.4	7.5	385	2.9	13.0	640	8.3	13.2	2285	30.1
Maize (Irrigated)	0.8	4780	4.0	0.2	6250	1.0	0.6	6500	3.9	1.1	5550	6.1	0.3	4900	1.6	0.2	6630	1.6
Sub Total	23.5		9.2	14.1		14.5	17.9		38.3	8.6		9.0	13.4		10.0	13.4		31.7
Total Coarse Grain	216.1		30.0	200.6		69.9	343.2		112.7	316.4		53.8	323.6		82.7	352.5		164.0

* No break-down by region available before the 1994/95 season
Totals may not add up due to roundings

Source: Namibian Early Warning & Food Information System

2. THE NEED FOR NEW OR IMPROVED ON AND OFF-FARM STORAGE

2.1 Production and self-sufficiency in cereals

Table 2 shows Early Warning data for Namibia coarse grain production in the NCA Regions and commercial sector. By and large harvests have been poor in the 1990s, but in 1997 there was an unusually good harvest. If we assume that annual per capita grain requirements are around 100 kg, the normal pattern has been one of deficit, though all Regions seem to have produced a surplus in 1997 - see Table 3.

TABLE 3: COARSE GRAIN PRODUCTION PER CAPITA BY NCA REGION

Region	Production per capita per marketing season			(kg)		
	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98
North-Central Regions	26	57	54	85	79	150
Kavango	36	59	113	54	93	119
Caprivi	14	133	52	36	70	115

Source: Namibian Early Warning System; official population projections based on last census

Such crude estimates of surplus and deficit are quite hazardous. The Namibian Early Warning System estimates per capita consumption to be 135 kg, but private industry uses much lower estimates (NAB, *pers. comm.*), on the grounds that the diet is quite diverse. Notably, the diet includes significant quantities of purchased maize meal, even in bumper crop years. On the other hand, the extraction rate (or milling yield) through traditional processing of mahangu is very low (50-60% according to trials carried out by Dendy, 1993), and this will tend to depress the size of the surplus.

2.2 Storage needs in Caprivi

2.2.1 Maize

Caprivi produces maize under two production regimes: flood-plain and rain-fed. Flood-plain production is more consistent, as farmers can generally get a harvest regardless of whether water levels are high or low; moreover high yields can be obtained without the addition of fertiliser.

There is uncertainty about the volume of production, though it is clear that there is much variability between years. According to Table 2, production in the 1990s has varied between a minimum of 400 tonnes in the El Niño year of 1992 to 10,800 tonnes in 1997. None of the sources we consulted could supply data on the proportion of production accounted for respectively by flood-plain and rain-fed maize.

We visited producers in a location called Zobue, and the findings are shown in Appendix 3. Production is severely handicapped by transport difficulties in an area where water-logging and the lack of roads mean that maize can only be moved out during part of the year, from August to March or April - and for part of this time with considerable difficulty. The following problems were noted:

(a) Despite harvesting from January, there is little incentive to move grain to market since the officially-regulated procurement system (which supports prices at above the fully free-market level) is not buying at that time. Apart from this, much of the grain has not dried out by the time that the floods come, in April. For these reasons grain is not moved to the market until August at the very earliest, and only with the greatest difficulty, using boats; most leaves by lorry when floods recede in October, and at this time procurement is well advanced. In 1997, this proved highly disadvantageous, given that by the time farmers got their produce to market, millers had already acquired their allocation, and their only alteratives were to sell to the NAB at the buyer-of-last-resort price (12% below the into-mill guideline price), or if not judged to meet exacting quality standards of the feed miller, at a further N$200 discount. Late sellers, mainly marooned flood-plain farmers, were penalised.

(b) Grain is stored on islands in the flood-plain in rudimentary stores and without chemical treatment. Consequently there are significant quantitative and qualitative storage losses (see discussion in Appendix 3). The farmer loses financially because, firstly, substantial numbers of cobs are rejected prior to threshing and, secondly, insect and mould damaged grain is often rejected by buyers of milling-grade maize and forced into feed-grade channels[1].

(c) Even when movement is possible, transport costs are high. Presently NDC offers a subsidised service - to ship from Zobue area in the flood-plain to Katima Mulilo, this costs approximately N$55 per tonne, but private hauliers charge around N$133 per tonne.

(d) The geographical dispersion and isolation of producers makes it difficult for them to develop a co-ordinated marketing strategy and maximise their bargaining power vis a vis buyers.

Problem (a) could be partly addressed by organising NAB procurement in February and March, but a thoroughgoing solution would involve building a network of raised roads across the flood-plain, a proposition which might prove unacceptable on grounds of cost and environmental impact. Problem

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[1] Some grain accepted for feed use did not appear to be highly infested. A possible explanation for this is that in a situation of over-supply at artificial support prices, unusually high quality norms have been set with a view to limiting volumes procured at the higher price.

(b) can easily be addressed by the application of simple storage technology (see Section 4.2). Problems (c) and (d) can be addressed if farmers concentrate their produce in commercial quantities in places like Bukalo, which are on permanent roads and relatively close to the flood-plain. However the economies of organising storage in such locations should be weighed against the possible organisational diseconomies of decentralised storage arrangements.

Transport costs out of the flood-plain can be minimised by hiring tractors and trailers on a continuous basis, so as to obtain volume discounts. Farmers' marketing advantage can be maximised by playing the market and attracting buyers from as far afield as possible. Their existing marketing strategy is to sell to millers or Government at support prices, but Namibia's price support system is increasingly being questioned on domestic policy grounds, and is being practically undermined by the liberalisation of the Zambian and South African maize markets, which has brought about wide inter-annual price swings in that market. In the future farmers may find that their best option is to play regional markets, accepting low prices when there are gluts, and storing for high prices when there are shortages.

While the brevity of our visit did not allow us to thoroughly research the situation, there are certain indications (i.e. the ability to produce with low inputs and in conditions of drought), that commercial maize production in flood-plain ares of Caprivi has long-term potential. By addressing the above-mentioned problems, it may be possible to stimulate Caprivi's maize producers.

Our preliminary projection of storage requirements for maize in Caprivi are as follows:

- On-farm storage - for domestic consumption, storage on cobs with husks is appropriate. In maize destined from the market, new arrangements are needed to minimise infestation.
- Off-farm storage - "Assembly Depots" are needed with capacity to handle variable quantities of maize, upwards of 1,000 tonnes per annum. While designed specifically to facilitate marketing by flood-plain producers, these should also assist dry-land producers.

2.2.2 Mahangu and sorghum

Early Warning data indicates that Caprivi produced 3,800 tonnes of mahangu and sorghum in 1997 (see Table 2), while according to preliminary CSB data, more than half the quantity produced is sorghum. These cereals are mainly grown in the Western part of Caprivi, in limited quantities, so that whether in good or bad years, most producers only need to store for a few months after harvest. The small minority of farmers who produce surpluses over and above their own needs can usually dispose of them without much difficulty, by selling to deficit producers or non-producers, as grain or beer, or as payment for services rendered. In the bumper production year of 1997, a few producers have approached Likwama Farmers' Co-operative Union (LFCU) to find additional outlets, and arrangements have been made to sell the grain to a local poultry producer. The quantity so far marketed in this way is quite small - about 20 tonnes.

Our preliminary estimates of storage requirements for mahangu and sorghum in Caprivi are therefore as follows:

- On-farm storage - adequate in terms of quantity. Time did not permit farm visits to assess the scope for improvements in the quality of storage, but there are likely to be storage problems similar to those noted in North-Central Regions - see 2.4.1 and 2.4.2 below.
- Off-farm storage - tens of tonnes in a high production year such as 1997, zero tonnes in a low or normal production year. This is being handled adequately through existing co-operative and trade mechanisms.

2.3 Storage needs in Kavango

2.3.1 Mahangu

According to Early Warning data, combined mahangu and sorghum production in Kavango was 11,800 tonnes in 1997, of which 8,000 tonnes were produced by subsistence farmers and 3,800 tonnes under the NDC's Farmer Support Programme (FSP) - see Table 2. The Central Bureau of Statistics found total production to be only 3,436 tonnes (which appears strangely low), and of this amount, 89% was mahangu and 11% sorghum.

A recent paper by the Rural Development Support Programme (RDSP) classifies NCA farmers into three categories as indicated in Box 4.

TABLE 4: RDSP CATEGORISATION OF NCA FARMERS

C1 or **"Advantaged"** farmers with a cropping area of over 11 ha, ownership of draught animal power, household labour force of 6 or more, and usually having surplus crops for sale. They are estimated to constitute about 10% of farming households.

C2 or **"Transitional"** farmers with a cropping area of 5 to 10 ha, ownership of draught animal power or with access to hire or borrowing, household labour force of 3 to 5, and often having surplus crops for sale. Estimated at 20% of farming households.

C3 or **"Disadvantaged"** farmers with cropping area of less than 5 ha, no ownership of draught animal power and only limited access to hire or borrowing, household labour of less than 3, and not usually having surplus crops for sale. Estimated at 70% of farming households.

In addition to these three, there is a fourth category of **"Mechanised"** farmers, who in 1997 planted between 25 and 400 ha of mahangu and sometimes smaller areas of cotton. They use tractors for land preparation and planting, apply fertiliser and have significant borrowings. There are 162 such farmers financed by NDC (160) and Agribank (2), and their largest concentration is in the area of Katji-na-Katji, at 90 km on the road from Rundu to Grootfontein.

Some 371 non-mechanised C1 farmers in Kavango Region also received production credit from Agribank, but at a lower rate (N$245 per ha) than their two mechanised borrowers (N$500 per ha).

We may now discuss the storage requirements of each group of farmers:

C3 farmers. These are more or less permanently in a deficit situation and supplies usually only last them for a few months. By and large, present storage arrangements, using traditional bins and baskets, are adequate and losses minimal.

C2 and most C1 farmers. After good harvests, they often have more mahangu than is needed to cover their normal annual requirements, and stocks often last beyond the next harvest. However, they rarely if ever store beyond two years. Surplus stocks from a good harvest will typically be kept to around April of the second year, and then sold if the farmer is sure that the next harvest is good. In the present circumstances, they do not consider marketing to be a problem, and they are handling their larger than normal stocks in the following manner:

- By paying "stick" labour with mahangu, instead of with purchased maize meal, as they do in deficit years

- By consuming more mahangu and purchasing less maize meal
- By using more for brewing
- By selling more locally in the community
- By building up reserves for future years

Given that mahangu is normally consumed along with purchased maize meal, it is easy for these farmers to regulate their use of each in relation to the abundance of local cereals. This applies to many, if not most, of the non-mechanised Agribank customers, who have limited surpluses and should be able to dispose of them locally **in small quantities at a time**. They can probably get prices of at least N$2 per kg in this way, whereas prices for larger commercial sales are unlikely to exceed N$0.80 per kg, and, even if Government intervenes, they are unlikely to exceed the price of N$1.45 per kg which was set for the Drought Relief Scheme in 1996. There will however be some Agribank customers whose surpluses are too large to be absorbed locally in this way.

There were no significant reports of insect damage and losses, and the mahangu we saw on farms visited appeared bright and clean. However, the findings in the North-Central Regions suggest that with mahangu stored for a year or more, significant storage losses are likely. Okashana 1 has a poor post-harvest reputation ("looks mouldy and goes to dust when stored for more than one year", "has an after-taste when machine processed", and "leaks water from the porridge"), but this could not be confirmed. Strangely we did not hear similar criticisms in North-Central Regions.

Mechanised and some larger C1 farmers. These farmers have substantial surpluses which they need to sell quickly with a view to repaying their loans. Off-farm storage arrangements are needed on or near the main roads, in order: (a) to prevent insect and mould damage which is likely to occur if their mahangu is left in the field; (b) to facilitate quality control, inspection and negotiation with buyers, and; (c) allow easy access for trucks. Bulking up produce in this way may also help NDC and Agribank to recoup their loans.

While these farmers have an immediate need for off-farm storage, it is not possible to project their long-term storage requirements because, as has been amply demonstrated in the NRC study, there is no clear rationale for the FSP which is leading them to produce large surpluses. **Until it is demonstrated that the FSP has a clear rationale, it will be imprudent to propose the development of further permanent storage facilities.** New off-farm storage facilities will only add to the costs of an unviable production and marketing chain - even if most of the capital costs are attributed to other unspecified social purposes. We discuss the marketing of commercial mahangu production in Appendix 4.

Total production of the FSP farmers and other farmers financed by Agribank is estimated at around 7,500 tonnes, as follows:

160 FSP producers (NDC estimate)	4,000 tonnes
2 mechanised farmers supported by Agribank	500 tonnes

371 non-mechanised farmers supported by Agribank	3,000 tonnes

We visited three FSP producers in Katji-na-Katji, the place of greatest concentration of production, which is located at 90 km on the road from Rundu to Grootfontein. The largest producer, Moses Kamalanga, had a marketable surplus of 264 tonnes, which he had already been allowed to store in the NDC warehouse at Katji-na-Katji (total estimated capacity 1,250 tonnes)[2]. Another producer (Bertha Nangalo) had about 50 tonnes 24 km off the road, mainly awaiting threshing, and in danger of spoilage through the effect of rain, insects and rats. She had requested roadside storage from NDC, and was awaiting a response. A third producer (Mr Katamba) had 20 tonnes already threshed, and stored in huts away from the road. He was fearful of spoilage and wanted to store in NDC's warehouse, but claimed lack of funds to pay for transport. All three farmers appear willing to pay for storage if this is required by NDC, given the need to avoid major losses which will otherwise occur.

As indicated above such storage is likely to be needed for most of the FSP and mechanised Agribank borrowers, and by some non-mechanised borrowers. The short-term need for off-farm storage arrangements in Kavango is estimated as follows:

FSP producers - 80% of 4,000 tonnes	3,200 tonnes
Mechanised Agribank borrowers - 80% of 500 tonnes	400 tonnes
Non-mechanised Agribank borrowers - 10% of 3,000 tonnes	300 tonnes
Total	3,900 tonnes
	i.e. about 4,000 tonnes

Here we assume that 20% of the mechanised and 90% of the non-mechanised production will be marketed independently, without passing through off-farm storage depots, or will be consumed locally. By carrying out its own survey, NDC can make a more accurate estimate of the storage requirement, and establish suitable storage locations. **However our own preliminary investigations indicate new mahangu storage requirements to be as follows:**

- Short-term off-farm storage to deal with the immediate problems faced by FSP producers and Agribank borrowers 4,000 tonnes
- Subject to a more in-depth assessment, assistance will be needed to improve on-farm storage. This should build on experience gained in North-Central Regions, where there is the most pressing need for such assistance.

[2] Kamalanga was also storing for local consumption in metal tanks; this experience should be evaluated with a view to recommending more widely.

2.3.2 Sorghum and maize

Quantities stored are quite small - provisional CSB data indicates less than 400 tonnes for maize and less than 1,000 tonnes for maize, and problems were not mentioned by farmers visited. For sorghum, the same general considerations apply as in the North-Central Regions - see Section 2.4.2.

2.4 Storage needs in North-Central Regions

2.4.1 Mahangu

Categorisation of farmers and general observations on requirements. RDSP defines farmers in the same categories as used in Kavango, there being an estimated 10% C1s, 30% C2s and 60% C3s. There are very few mechanised farmers, and most of these are primarily seed producers. There is no project along the lines of the FSP.

A study by NOLIDEP in Omusati and Western Ohangwena Regions (Blanc, *pers. comm.*) indicated that only about 5% of farmers were regularly interested in marketing their mahangu, while some 45% were sometimes interested. 25% of farmers were described as being in "survival conditions" and had too little production to be concerned about storage problems, while 25% of farmers were interested in storage but not in selling.

Our own visits to farmers in these two Regions confirmed this general picture. A large part of the farming population (corresponding to the C3 category) never produces enough grain to satisfy their domestic requirements, and consequently has little or no storage problems. The other farmers visited sometimes produce surpluses, but their main objective is domestic food security, and selling is very much an incidental activity. Farmers seek to guarantee their food security by accumulating reserves, and only when these reserves have risen to two years consumption or more does selling become a serious preoccupation[3].

In normal circumstances, farmers only sell small quantities at a time, by the *lata*, to pay school-fees, hospital expenses etc.. Gifts to relatives, particularly from poorer areas, are also common. The old grain is consumed and sold before the new grain, which is stored for future needs.

The experience of the Drought Relief Scheme gives some idea of farmers' over-riding concern with food security. The price paid to farmers on-farm was N$1.45 per kg, far in excess of the price which according to the NRC study, private industry might conceivably pay (N$630 to N$840 per tonne), yet only 483 tonnes were collected, less than 1% of that year's production (51,900 tonnes according to Table 2). With the bumper harvest of 1997, farmers are clearly prepared to sell for lower prices; indeed the Northern Namibia Farmers' Co-operative (NNFC) have already identified farmers wishing to sell

[3] During this visit, two years storage was the longest that was seen, though one farmer claimed that he would go on storing for three or more years if supplies permitted. During his previous visit to Namibia, Hindmarsh observed grain claimed to be stored for three years.

510 tonnes for N$0.80 per kg. Nevertheless this price, and the current market price delivered to mills in the Ondangwa-Oshakati area (N$14 per lata = N$0.82 per kg) is at the top end of the price range indicated in the NRC study. Moreover, if a major buyer were to enter the market, it might force the price over the N$1.00 per kg mark, rendering the processing unviable[4].

The implication of this is that when a bumper year follows years of poor to mediocre harvests, as happened in 1997, most of the surplus will be used for stock-building, and there will be only limited offtake for off-farm use. The need for off-farm storage will be correspondingly limited, and this can probably be easily provided by local trading companies (e.g. Punyu, with its warehouses scattered around the North-Central Regions).

In the event of repeated large harvests such as those in 1997, the price of mahangu would probably fall heavily, as farmers, having already sufficient reserves for the year's consumption, seek to unload their surplus production. Given inelastic demand among local consumers, prices will quickly drop to levels at which it can be sold in Windhoek for animal feed; according to NRC the price for 1,000 to 2,000 tonnes might be between N$650 and N$770 per tonne ex-warehouse Oshakati. In this case, there will be a need for considerable off-farm storage for the purpose of bulking up produce in accessible places where it can be held prior to delivery. The storage requirements are likely to exceed the limited capacity that existing traders can provide, and there is likely to be a need for additional temporary storage facilities.

Let us assume that there is a 40,000 tonne surplus in 1998[5], and that there have been off-farm sales of 5,000 tonnes since 1997. Farmers decide to increase their stocks by 15,000 tonnes over the level held at the 1997 harvest. They therefore seek to sell 20,000 tonnes onto the market (40,000 - 5,000 - 15,000 tonnes = 20,000 tonnes). Assuming that the storage capacity is used twice, with fresh stock being brought into storage as grain is shipped off to the user, the required storage capacity is 10,000 tonnes.

The likelihood of two bumper harvests in succession is quite low, and it has not happened since records began in 1990. The largest harvest was in 1997, when there was a combined millet and sorghum crop of 117,100 tonnes. The next largest harvest was 65,000 tonnes in 1990, which if adjusted by 3% annual population growth, would be equivalent to 80,000 tonnes in 1997. There are three factors which could increase the level of harvests over the next decade however: (a) a return to more normal rainfall levels; (b) increasing use of short-season varieties, allowing farmers to plant a second time, if their first seed fails, and; (c) increasing usage of the heavily subsidised fertiliser provided by the Japanese. In view of these considerations, our best estimate is that there will be repeated bumper crop

[4] Other comments, to the effect that millers are currently able to procure mahangu at N$14 per lata **without advertising**, suggest that supply is on the contrary highly price-elastic - hence considerable quantities can be procured at this price.

[5] In reality it is unlikely that there will be a bumper crop in 1998, given the present *El Niño* conditions.

conditions leading to heavy sales at least once in ten years (at most twice), with smaller commercial surpluses (less than 5,000 tonnes) being available in anadditional two out of ten years. Assuming that stocks are turned over twice, the maximum storage requirement in the latter years is 2,500 tonnes.

On-farm storage requirements. Losses for mahangu appear to be unusually high due to the practice of storing the grain threshed and retaining surpluses on farm to provide about two years' supplies. Since the oldest crop is eaten first, insect infestations have two years to develop.

Mahangu is stored threshed in spherical, woven baskets made from Mopane bark and branches, and lightly mudded inside. They range from 250 kg baskets to 2 metre diameter structures of around 3 tonnes capacity. Producers begin to notice insect damage within a few weeks of filling the baskets. The moth, *Corcyra cephalonica* is the most significant pest causing losses which could (subject to confirmation through trials) be up to 10 per cent in the first year of storage, increasing to around 30 per cent in the second year[6]. These moth infestations result in masses of grain held together by webbing (silk) produced by the larvae as they move through the grain seeking a pupation site. Many individual grains have their embryos removed by the feeding larvae. In order to use the grain, they have to be rubbed and sieved to remove the webbing, or alternatively the masses of clumped grain are fed to chickens.

This type of infestation is unusual in farm-stored mahangu, because producers in other countries store mahangu grain unthreshed, which is unattractive to the pest. Producers we visited recognised the damage and all were keen for a solution to the problem. By guaranteeing the physical integrity of their produce, they can moreover decrease the quantity stored to attain a given level of food security. At the same time improved on-farm storage will render industrial utilisation more feasible; much of the product currently sold is hardly of suitable quality, and might well be rejected.

For farmers wishing to acquire new storage structures, or replace existing ones, the cost of Mopane baskets is itself becoming a problem, as trees are becoming increasingly scarce and the artisans making them are having to go further afield to find suitable raw materials. For structures with capacity from 250 kg to 3 tonnes, we were informed of prices ranging from N$250 to N$1,000, i.e. a range of approximately N$333 to N$1,000 per tonne of storage capacity[7]. As we show in Section 4.3, it may be possible to find competitively-priced alternatives, which moreover provide an effective barrier against infestation and can be fumigated.

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[6] Likewise, Wohlleber (*pers. comm.)*, reports certain varieties of mahangu being attacked by storage pests other than the moth *Corcyra*. Dr Leuschner (ICRISAT, Bulawayo) has carried out relevant research.

[7] We emphasize the approximate nature of this estimate, which needs to be refined through further fieldwork. The shape of containers is non-uniform and volumes are difficult to estimate. Owners usually were usually unsure of their capacity.

2.4.2 Sorghum

Sorghum is produced on a small scale in relation to mahangu. MAWRD figures show average production throughout the NCA areas from 1990 to 1996 as 13.8% of the combined sorghum and millet total; preliminary CSB data shows the percentage for the North-Central Regions in 13.3% in 1995 and 16.6% in 1997. Sorghum is used almost entirely for making beer. It is stored threshed, in similar containers to those used for mahangu, but because of the low level of production, storage capacity, whether on or off-farm, imposes no constraint.

Threshed sorghum is susceptible to the same pest which attacks threshed mahangu and, in addition, is susceptible to a range of pests which attack other threshed grain, including maize. Red sorghum is much more vulnerable to attack than white varieties and threshed grain more susceptible than unthreshed. Consequently, storage pests seriously restrict farmers ability to store red sorghum, and several farmers requested assistance in addressing the problem.

2.4.3 Pulses

Farmers also store beans and cowpeas, and though these were not included in the terms of reference, it is worth noting that their storage is severely constrained by infestation. This problem needs to be addressed as a matter of priority. An interesting approach adopted by one farmer is literally to drown the insects. She soaks the pulses in water overnight, puts them in the sun to dry for three days, and then puts them in a bag or basket. It is worth experimenting with this procedure.

In summary therefore, storage needs for in North-Central Regions are as follows:

- In years of poor or average crops, sufficient on-farm storage capacity can be provided by the farmers themselves, and traders procuring stocks to satisfy the needs of deficit farmers (as described by Keyler, 1995).
- In the event of a single bumper-crop year, following on from poor crop years, limited additional off-farm storage will be needed for mahangu, and this can probably be provided by existing trading networks.
- In the event of a succession of bumper crop years, substantial off-farm storage capacity (up to 10,000 tonnes) may be needed to facilitate efficient marketing of surplus mahangu for industrial use.
- New on-farm storage technologies are required to minimise quantitative and qualitative losses caused by insects with mahangu, sorghum and pulses.
- Farmers require new cost-effective storage structures which they can acquire as alternatives to the traditional Mopane baskets.

2.5 The need for Strategic Grain Reserves

The case for Strategic Grain Reserves has already been studied in two previous studies, by Jones (1992) and MAWRD (1997), with generally negative conclusions.

The purpose of such reserves is normally to allow Government to react quickly to food emergencies; they are not price support instruments for the benefit of producers, but are by contrast designed to assist consumers whose food security is under threat, since they cannot afford food on local markets. They are typically recommended in countries which are likely to have difficulty in quickly obtaining alternative supplies either through domestic purchases or imports - these tend to be landlocked countries with relatively fragile economies, and long supply routes from the international market, e.g. Mali and Ethiopia. These features do not characterise Namibia. It has ready access to imports from South Africa, from the Americas (through Walvis Bay) and, in years of surplus, from landlocked countries of the interior of Africa (Zambia and Zimbabwe).

Jones (1992) states that "the main justification for public national level reserves, if one exists, would therefore be a mechanism for reducing reliance on import routes which are controlled by South Africa". While hostilities or closure of trading relations with South Africa are, to say the least, unlikely, it is even less likely that the international community would allow South Africa to blockade Walvis Bay and Namibia's other points of entry. There seems to be little reason for such defence-related arguments.

The costs of reserves are high - MAWRD estimates this at 20% of the grain cost, but based on international comparisons, the full cost of storing grain for a year in warehouses, in money terms, may be even higher.

TABLE 5: ESTIMATED COST OF STORING MAHANGU PER ANNUM		
	Procurement price	
	$600/tonne	**$1,200/tonne**
In-out handling and management	N$ 23	N$ 23 per tonne
Annual storage charges - at least	N$ 60	N$ 60 per tonne
Interest on capital, say 20%	N$120	N$240 per tonne
Total	N$203	N$323 per tonne
Percentage of total grain cost	33%	27%

In a country where farmers hold large stocks of grain for food security purposes, it is they who in effect provide a reserve stocking function, at no cost to Government. As noted above, many NCA farmers try to hold two years' stocks of mahangu and only sell their reserves. For Government to create its own reserve will simply duplicate this activity; moroever if, as with the Drought Relief Scheme it subsidises the procurement price, it will encourage farmers and traders to destock, so that the net increase in national stocks (held on-farm, in the private sector, and by Government) may be minimal.

A major drawback to Strategic Reserves is that they almost inevitably become dominated by short-term political considerations resulting in:

(a) poor pricing and delayed buying and selling decisions, resulting in unnecessary financial losses to the storage agency and the public purse;
(b) damage to local grain markets, as traders refrain from purchasing and storing (due to politically motivated interventions by the public sector), and farmers cease to respond to normal market signals because the Strategic Reserve has been used to prop up prices at uneconomic levels.

The latter has happened in the Southern Highlands of Tanzania. There is also the case of Botswana, where the Government collected large quantities of Sorghum as a food stock, and was then unable to sell them competitively in the local market (Rohrbach, *pers. comm.*).

In Namibia, the effect of politically-inspired market interventions is exemplified by the Drought Relief Scheme of 1996. Government paid a price far in excess of what private buyers would have been prepared to pay, and while this was of immediate benefit to sellers, it provided a distorted price signal, encouraging some farmers to grow more mahangu in the next season, and creating a lobby in favour of continued Government procurement, regardless of the marketing prospects. If a Strategic Grain Reserve were created, the lobbying in favour of such procurement would be even greater.

In creating a Strategic Grain Reserve therefore, Namibia risks repeating costly mistakes made by newly independent African States in the period 1960 to 1985, as well as some made by European countries under the Common Agricultural Policy.

3. ISSUES TO BE CONSIDERED IN DESIGNING STORAGE SOLUTIONS

3.1 Introduction

In this Section, we discuss some of the more general issues raised in the Terms of Reference, i.e. on-farm versus off-farm storage (detailed task 3); the case for subsidised storage : bag versus bulk (detailed task 2); bagged storage options (part of detailed task 4); co-operatives (detailed task 7); the role of the NDC (detailed task 8).

3.2 On-farm versus off-farm storage

This is a matter for the market to decide. Farmers will generally store mahangu on farm because co-operative storage involves location-related difficulties and a series of institutional risks:

> Will the product be safe?
> Will I get back what I put in?
> Will my clean grain subsidise the moth-eaten grain of my neighbours?
> Will my grain be sold on credit to neighbours who never repay?
> Can I trust the treasurer (who is literate, while I am not)?
> Do I want to spend time at meetings and risk getting into acrimonious discussions etc.?

Given these factors, and the prospect of reducing storage losses to negligible levels through better on-farm practices and structures, the benefit-cost ratio of off-farm versus on-farm storage for home use and sale in local markets is likely to be overwhelmingly negative.

For such reasons, village storage projects often fail. This was noted by Berg and Kent in their study of Cereal Banks in the Sahel (1991), and by NRI in a review of the Tanzanian Village Stores project (see Coulter and Golob, 1992). During the 1980s, donors built about 1,000 village stores with 300 tonne capacity, but due to the collapse of the single-channel marketing system, and farmers' preference for on-farm storage, they were largely being used for other purposes - e.g. civil registries, Party offices, and as village halls.

Farmers may organise off-farm storage on a co-operative basis, when they have some compelling reason, e.g. the need to have readily bagged stocks in a location accessible to buyers, with a view to meeting immediate orders. As discussed in Section 2.4.1, this may occur in the event of repeated bumper harvests of mahangu. In cost-benefit terms the prospective increase in sales revenue, which may be 20% or more, outweighs the increased risks of storage losses, embezzlement etc..

For the same reason, traders or processors may organise off-farm storage. As demonstrated by Keyler (1995), they may also be motivated by the prospect of speculative gains through seasonal storage.

3.3 The case for subsidised storage

We can see no case for subsidised storage of mahangu. Subsidised inputs and purchasing have already brought about an increase in production, particularly under the FSP in Kavango, in the absence of an effective market to absorb the surplus thus created. Further subsidies, at the storage level, will tend to perpetuate the belief that Government will support mahangu production regardless of cost.

Subsidised storage will moreover discourage private operators from entering the warehousing business, and is also likely to slow the development of Co-operatives and similar organisations in this field - why organise one's own storage if one can get Government to do it?

3.4 The case for bulk storage

Off-farm storage of surplus production would probably be at assembly depots in production areas, so as to minimise transport, and beside main roads so as to facilitate the access of buyers and trucks. Bag or bulk handling systems could be used, however since bulk storage is characterised by high capital costs, vis a vis bag storage alternatives, it is likely to be totally uneconomic - see worked example for maize storage in Table 6.

TABLE 6: CAPITAL COSTS OF BAGGED STORAGE OF MAIZE IN WAREHOUSES, VERSUS BULK STORAGE		
	Bags in warehouses	**Bulk**
Capital cost/tonne capacity (1)	N$400	N$600
Estimated throughput of mahangu as a percentage of capacity utilisation (2)	60%	60%
Capital cost/tonne average annual throughput	N$667	N$1,000
Discount factor, 10%, 20 years life	8.5	8.5
Annualised cost/tonne throughput, assuming cost of capital at 10% and 20 years useful life	N$78.4	N$117.6
Estimated sale price/tonne maize	N$800	N$800
Capital cost of store as percentage of sale price	9.8%	14.7%

Notes: (1) For warehouse assume brick walled building, 18m span, 4.5 m to eves - storage capacity 2.0 tonnes/sq. m with maize. (2) Assuming 5 years/10 there is no surplus and therefore no crop to be stored, and 5 years/10 there is a surplus and stores are filled to 80% capacity. Average capacity utilisation = 40% x 1.5 turnovers of stock = 60%.

Notwithstanding the very rough nature of this calculation, it shows that in a situation of fluctuating supply and low capacity utilisation, the cost of permanent off-farm storage facilities per tonne of mahangu processed will be very high, above all for silo facilities which can cost as much as twice as much as bag stores, per tonne stored. Certain of the assumptions in Table 6 are quite favourable to bulk storage. In reality, various factors could make the economics of bag storage even more favourable: (a) cheaper bag stores could be built, with corrugated iron walls; (b) taller bag stores could be constructed, allowing larger quantities per square metre of storage space; (c) the cost of bulk storage could be higher than indicated, since sandy ground conditions raise the cost of civil works, and; (c) surplus conditions may occur in only 3 years in 10, not 5 years in 10 as assumed in Table 6.

At the same time, bulk handling brings few compensatory savings. There are no savings in bag costs, since the mahangu must be shipped from the farm in bags, and likewise from the silo to the final user's plant (given lack of bulk wagons, and the opportunities for cheap backhaul using conventional trucks). There will consequently be double-handling as grain must first be poured into the silo hopper, and subsequently rebagged for dispatch to the end user. Typical handling charges for loading and unloading a bag store are N$7 per tonne (US$ 1.49), and while this is high by standards of many African countries, it is small in comparison to our estimated incremental capital costs associated with bulk storage (about N$39.2 per tonne).

Bulk storage is also disadvantageous in that it cannot be used for other purposes. Warehouses can be rented out, they can store agricultural implements or can even be used as village halls. In order to avoid disastrous losses, bulk storage requires high levels of management. By contrast bag storage can be locally constructed, it is flexible, requires relatively unskilled labour and is much easier to manage.

The same arguments apply to mahangu, though the savings through bag handling would be somewhat less, due the greater bulk density of the grain (1.2 cu m/tonne against 1.6 cu m/tonne for maize).

Despite these observations, there are situations in developing countries where bulk storage is a paying proposition, invariably where there needs to be a fast turnover of grain, for example in reception silos at mills, at rail-head loading depots or in ports. The logic for bulk handling in such circumstances is that it allows one to economise on the use of other costly assets in conjunction with which it operates, e.g. it prevents demurrage at ports, it allows trains to turn round faster. Following the same logic, a future mahangu miller operating on a commercial basis may seek to install silos to handle raw material arriving from the field.

3.5 Open storage versus warehouses

Investment cost for brick walled warehouses are indicated in Table 4. At the other end of the spectrum is pole storage. In Zimbabwe, pole storage is carried out on a massive scale with single stacks of 5,000 tonne capacity, the cost in poles, bitumenised canvas tarpaulins etc. is approximately N$12 per tonne stored[8]. Tarpaulins are the major cost and they can be used for four seasons. The capital costs of Likwama's storage operation, using only 250 tonne stacks is not surprisingly much higher (N$35 per tonne). Given that smaller stacks will be required, we estimate the range of feasible cost in the Namibian situation probably lies in the range of N$30 - N$40 per tonne.

If the stacks are to be placed on permanent plinths instead of poles, one must invest approximately N$275 per sq. m, and costs rise considerably (see costing in Appendix 8).

The estimated investment cost per tonne of storage capacity for maize, excluding perimeter fences, access roads, offices and working capital, is as follows:

[8] We assume minimal civil works costs, but this may vary according local conditions.

TABLE 7: INVESTMENT COST/TONNE CAPACITY WITH MAIZE	Per sq. m	Per tonne
Bulk storage - min.		N$600
Warehouse - brick walls	N$800	N$400
Warehouse - corrugated iron walls	N$655	N$328
Open storage on permanent plinths - 5,000 tonne stacks		N$ 80
Open storage on poles, Namibia		N$ 30 - 40
Open storage on poles, Zimbabwe		N$ 12

Notwithstanding the very rough nature of this calculation, it shows the large differences in investment costs between the different structures. If, as is to be expected in Namibia, capacity utilisation is very low, the difference will be correspondingly greater.

On the other hand, storage in warehouses brings several important advantages, including:

- lower risk of theft or storage losses, including losses due to stackburn
- lower recurrent costs, avoiding the need to reproof tarpaulins, and to replace poles and tarpaulins every four years
- easier management

However, cost advantages are unlikely to compensate for higher initial capital costs. Let us assume that storage losses can be reduced by 2% in value terms; there is also a saving in replacement of tarpaulins, poles etc. every four years. The period required to pay back the additional investment can be calculated as follows.

TABLE 8: PAY-BACK ANALYSIS FOR WAREHOUSE VERSUS POLE STORAGE

(a) Savings in recurrent costs, per tonne storage capacity:			
Assume maize is worth N$800 per tonne			
Annual reduction in losses	= 2% of N$800	=	N$ 16
Average annual savings in replacement of tarpaulins, poles etc.	= N$40 / 4	=	N$ 10
Average annual costs		=	N$ 26
(b) Increase in initial capital costs. per tonne storage capacity:			
Cost of warehouse with corrugated iron walls		=	N$328
Less cost of pole storage - say		=	N$ 40
Increased costs		=	N$288
(c) Pay-back period, assuming 100% use of storage capacity:			
(N$328 - N$40) / N$26 per year		=	11 years

It takes 11 years to pay back the extra cost - but only in the inconceivable event that the facility is used to full capacity every year. Otherwise pay-back takes much longer. Such a pay-back periods are completely unacceptable under any normal investment criteria.

Given Northern Namibia's situation of fluctuating supply, and correspondingly variable need for off-farm storage, the use of the cheapest technology (storage on poles) is likely to prove the most financially sound alternative. However, where there are very serious security problems, permanent warehouses may be preferable.

3.6 Co-operatives

Detailed task 7 in the terms of reference asked us to:

Assess the financial and institutional feasibility of NCA co-operatives investing in storage facilities using finance obtained at Agribank interest rates. Assess the advantages and disadvantages of co-operatives establishing off-farm storage in combination with processing facilities.

Comments on specific opportunities for farmer co-operation are made in the following Sections. In this section we discuss the topic in general terms.

During our visits we encountered four co-operatives: the Likwama Farmers' Co-operative Union (LFCU - in Katema Mulilo); the Katemo Farmers' Co-operative (Rundu); the Northern Namibian Farmers' Co-operative (NNFC - Oshakati), and the OMAFA Co-op (Ohangwena). LFCU and NNFC have been built up on a regional basis as multi-service entities, having their own branch retail stores selling agricultural inputs and consumer goods. LFCU is both a co-operative and a farmers' union, and much of its activity is concerned with lobbying Government on behalf of its members. It is composed of 20 local associations which elect members to the Union board. NNFC has five branches. Both organisations have 400-500 paid-up members, and their capital consists of membership share subscriptions and grants, and they have no so far generated reserves from their operations. OMAFA is a newer creation, and is also seeking the same regional coverage.

LFCU has a mahangu mill (dehuller and hammer-mill) working almost entirely on a custom basis, and NNFC (together with MAWRD) recently commissioned CRIAA to carry out a feasibility study with a view to establishing its own mahangu marketing function. NNFC's initiative has had a particularly fortunate outcome, in educating commercially-oriented farmers about the workings of the mahangu market - and giving them a greater sense of reality about the sort of prices which the market can bear.

Katemo is a smaller local entity with 32 members. Its main activity is custom milling of maize and mahangu and it mills little more than 100 kg per month. Having endured a management upheaval in 1994, its financial situation prevents expansion of activities.

The Namibian Co-operative movement is young, and is receiving considerable outside support. With a new Law passed in 1996, it is being promoted along classical voluntary lines, following the principles established by the International Co-operative Alliance, and is therefore avoiding the disastrous experience of many countries (e.g. Tanzania, Zambia and Eastern European countries) during the era of State-domination. At that time co-operatives were widely used as instruments of Government policy, and incorporated into single-channel marketing systems, and the sovereignty of the membership was severely curtailed.

NRI recently carried out a review of co-operatives and similar *Farmer-Controlled Enterprises* (or FCEs), organised along voluntary lines since structural adjustment, in Africa - see Appendix 5. In relation to the Namibian movement, the findings suggest that there should be more emphasis on strong village-based organisations, rather than the regional structures which have so far dominated the scene. In fact we were informed that such a change is being sought by the Division of Co-operative Development at MAWRD.

To develop a strong co-operative movement, there is a need for small homogeneous, village groups with clear member-driven agendas, and where members have frequent face-to-face interaction. They should engage in simple marketing or procurement activities in which they can achieve rapid success, and where they have a comparative advantage vis a vis other suppliers of these services.

Grass-roots initiative can be stimulated if NGOs and sponsoring institutions invest in basic literacy, numeracy and literacy skills. Apart from this, farmers need to be encouraged to identify those activities which they can best carry out together, and to leave to others (or contract in) those services which can best be carried out by private suppliers.

Subsidies and concessional finance can weaken co-operatives, not because they are inherently bad, but because they tend to attract members looking for free resources, and not those who genuinely wish to solve their problems through co-operation.

Providing they are united and well managed, co-operatives seeking to invest in storage face similar prospects to private traders. Indeed they may enjoy certain advantages due to their better knowledge of where surpluses are. As with private traders, oportunities for financially profitable operations will depend upon local circumstances. In Section 4.2 (below), we show how a co-operative in Caprivi might make a profit by storing maize speculatively at "Assembly Depots". In Section 4.4, we discuss co-operative involvement in the periodic storage of mahangu surpluses in North-Central Regions.

In some cases it will be financially feasible to add processing facilities to local storage and assembly operations, particularly custom-milling facilities which serve local needs. However, this is an area where FCEs are much more prone to failure, due to the higher management demands of jointly managing and maintaining complex pieces of equipment. Individual owners tend to run their machines longer and maintain them better than do committee-based organisations.

3.7 The potential role of NDC in grain storage operations (detailed task 8)

NDC has a role to play in helping to rescue this year's harvest by mechanised mahangu producers in Kavango Region, and ensuring that it is properly stored and marketed. NDC's knowledge of the business, its financial interest in the crop, and its ownership of various warehouses, make it a particularly suitable entity to carry out this role.

Based on our observations at Katji-na-Katji and Omega (Caprivi Strip), NDC staff need some storage training. While stores we visited were being kept clean, there is scope for building better stacks, which would for allow greater utilisation of available space, and (by keeping the walls clear), fumigation under plastic sheets.

As regards the future, we suggest that NDC's role be reviewed with a view to privatisation of the whole or parts of it. In reality the NCA needs some sort of agency to promote agricultural development, by focusing on the identification and exploitation of long-term development opportunities, and MAWRD is logically the organisation to fulfil this function. In doing this the Ministry might need to provide seed money for risky commercial endeavours, but only in situations where Government involvement is finite, and where it is clear that support can be withdrawn after a short period leaving the activity to survive on its own feet. Government should seek to work itself out of a job.

NDC by contrast, seems to be focused on short-term political priorities, and for this reason and despite the initiative of its staff, it cannot make much impact in the long-term. This is illustrated by its involvement in mahangu milling at Musese. As indicated in Appendix 4, the plant should have been run as a pilot operation for product development and test marketing of mahangu meal, particularly with a view to generating the interest of larger commercial players. Instead of concentrating on proving the product in this way, it has been run without regard to financial viability, and its very existence has been used as a rationale for developing commercial production in Kavango Region.

In the event of NDC's privatisation, some thought should be given to how NDC warehouses could be best used. One possibility is the leasing of such buildings to specialised private storekeepers, who would work along the lines indicated in our discussion of maize in Caprivi.

4. PROPOSED STORAGE SOLUTIONS

4.1 Introduction

In this Section we seek to answer the main questions posed under detailed task 4 of the TOR, and propose how Namibia can address the specific storage needs highlighted Section 2, i.e.:

- better storage of flood-plain maize, on and off-farm, in Caprivi (Section 4.2);
- improved on-farm storage of mahangu and sorghum (Section 4.3);
- emergency off-farm storage of mahangu in Kavango, to deal with the immediate problems faced by FSP producers and Agribank borrowers (Section 4.4), and;
- intermittent or occasional surges in off-farm storage requirements for mahangu in NCA regions, due to a succession of good harvests (Section 4.5).

Appendix 6 contains notes on the maintenance, operation and management of storage structures (detailed task 5), and also discusses means of minimising losses by the storage agency (detailed task 6), while Appendix 7 provides advice on warehouse construction.

4.2 Improving storage of flood-plain maize in Caprivi

Recommendations are needed to protect grain from *Sitotroga* moth until threshing and *Sitophilus* weevils and rodents while in bags after threshing (see Appendix 3 for discussion of these pests)[9]. As margins are tight these recommendations need to be innovative.

Grain should be dried and threshed as quickly as possible, to minimise *Sitotroga* damage. Pesticides such as Actellic dust can then be applied to the threshed grain at 0.5% by weight as the bags are being filled to control *Sitophilus*. Rodent damage can be minimised by stacking bags on pole platforms with metal rat guards around the uprights.

The cost in such improvements can probably be recovered quickly through reduced storage losses and better selling prices. The cost of the simple structure we propose should be recovered through the decrease in rat damage. As regards our proposed approach for reducing insect damage, let us assume that:

(a) the on-farm sales value of the maize is N$500 per tonne, and;
(b) actellic to treat one tonne costs the farmer N$38, based on experience elsewhere in Africa (it is not currently on sale in Namibia).

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9 The arrival of the Larger Grain Borer (*Prostephanus Truncatus*) should also be forseen.

In this case the farmer will need a 7.6% saving in the quantity of grain lost and/or equivalent gains in the value of the grain sold to recover the cost of the insecticides. Presently, farmers stand to gain about N$200 by delivering to NAB's milling pool rather than to the feed-milling company, Feedmaster, so that the prospective benefit:cost ratio, assuming no additional labour costs, is 5.3:1.

Our conversations with flood-plain producers suggested that farmers may be interested in investing in metal silos - of the kind described in Section 4.3 below. They will provide more effective protection against rats and insects, but it is doubtful that the benefits will justify the extra cost. Moreover grain stored in bags has the advantage of being in a form ready to ship to market. Notwithstanding, farmers may have other undisclosed reasons for preferring the silo (e.g. theft), so it is worth further exploring their interest in this alternative.

As indicated earlier, farmers can address marketing and transport problems if they concentrate their produce in commercial quantities at "Assembly Depots". Storage may be decentralised in places like Bukalo, which are on permanent roads and relatively close to the flood-plain, or centralised in Katima Mulilo. As we indicated in Section 1.2.1, the choice between centralisation and decentralisation hinges on one's view as the feasibility and relative cost of successfully organising decentralised storage. Transport costs out of the flood-plain can be minimised by hiring tractors and trailers on a continuous basis, as a sort of logistical exercise which the farmers themselves organise.

This is the sort of linkage activity in which the grass-roots FCEs, of the kind discussed in the previous Section, are most likely to succeed. It is a simple operation, in which the individual co-operators are motivated to achieve practical improvements of direct benefit to themselves, and where they enjoy a comparative advantage over private middlemen, since they know best where the stocks are, and how they can best be collected.

Linkage activities can be broken down into various functions, i.e.:

(a) co-ordinating the transport to, and assembly of grain at, Assembly Depots;
(b) receiving, controlling quality and storing the grain at Depots;
(c) negotiating sales with NAB or private buyers, and;
(d) organising payment to members.

Given what we have said previously about the need for FCE's to concentrate on what they do best, it is worth considering exactly who is best qualified to carry out which of these functions. The FCE is best qualified to carry out Function (a) and most of (d), as this involves direct contact with the farmers themselves, a tiresome activity for any outside agent. The FCE might also control decentralised Depots, but it would probably be preferable for them to be controlled by a third party, i.e. a professional storekeeper. Having a third party as arbiter might diminish potential disputes between members over quality and other matters, and he/she might possibly act as *collateral manager* vis a vis creditors, i.e. while they are waiting for the produce to be sold, farmers might gain access to *inventory credit*, based on the value of stock. At the same time, stock which is held by a reputable storekeeper could be sold forward, giving the buyer the security that the seller will perform (i.e. delivered) as specified in the contract. If the farmers were to manage their own stock both banks and buyers will probably be reluctant to consider such options.

The storekeeper might be one of the storekeepers (Mr Basson, LFCU) who was appointed to manage stocks by NAB in procuring the 1997 maize pool, or another party. Such a party should be chosen purely on professional and financial criteria. He/she should have a first rate reputation with the trade and above all the banks, and be trusted by the farmers. Financial guarantees, in the form of assets or bonding arrangements may also facilitate the development of this activity. The stock should moreover be insured.

Given that local farmers' groups will have limited access to market information and prospective buyers, function (c) could also be entrusted to a third party, on a contractual basis. Grain of a given quality could be assigned to a pool, and farmers paid on the basis of the average sale price realised for the pool, less expenses, including the seller's commission.

We do not recommend that Government stores the grain itself, but that it concentrates on the training and professional development of parties interested in grain storage. In this regard we feel that NAB has done well by entrusting storage of the 1997 pool to specialised agents.

As regards off-farm storage structures, and bearing in mind the arguments in Section 3.5, we would recommend starting with storage on poles, which will avoid overloading the cost structure of the incipient marketing operation. Moreover, there may be a case for Caprivi's flood-plain farmers diversifying to more profitable crops; until the options have been appraised one should avoid investing large sums in a maize-based marketing system.

Costs should be covered by charges on users. In managing part of NAB's maize pool for 1997/98, LFCU is charging N$60 per tonne, and with this fee, it should recover its total investment in plastic covers in a single year. Notwithstanding this, LFCU needs to make certain changes to the way in which it is protecting the stacks, *as a matter of some urgency* - see Appendix 8 for details.

In order to determine whether farmers can recover their storage charges with an operation of this kind, one needs to carry out a full planning exercise and feasibility study, with the involvement of the farmers themselves. The operation may well prove feasible, since farmers will gain through reduced transport costs and through being able to negotiate with buyers from greater strength. Large volumes of maize of known and uniform quality, in accessible locations, will fetch much better prices than small scattered and unseen lots.

Let us make a very simple cost-benefit calculation, to show how this might work[10]. Let us assume that the NAB-regulated procurement system is phased out, and that farmers are required to play the market on their own. After produce has been assembled at the off-farm depot, it is then stored there for three months before sale. The FCE succeeds in reducing transport costs by N$20 per tonne, and increases the selling price by $250 per tonne, from N$500 to N$750. The cost of capital invested in the stored crop is assumed to be 5% for the three month period. The benefit-cost ratio is calculated as follows:

TABLE 9: HYPOTHETICAL COST-BENEFIT CALCULATION FOR AN IMPROVED MAIZE HANDLING AND STORAGE OPERATION IN CAPRIVI FLOOD-PLAIN AREA

		Per tonne of maize
Benefits:	Additional revenue	N$250
	Transport savings	N$ 20
	Total	N$270
Incremental costs:		
	Storage insecticide (for on-farm use)	N$ 38
	Off-farm storage charges	N$ 60
	Interest for 3 months - 5% of N$500	N$ 25
	FCE's management charges	N$ 20
	Sales commission (2% of N$700)	N$ 14
	Total	N$157
Incremental revenue to farmer		N$113
Benefit:cost ratio	= 270/157 =	1.72

4.3 Improving on-farm storage of mahangu and sorghum

As far as we know the *Corcyra* moth does not come from the field but enters the mahangu when it is in storage. If this is the case, there will be no need for insecticide and the solution to the problem is to place it in a sealed container which the moth cannot enter. One way in which this might be done is to continue using the traditional baskets, and to line them with thick plastic sheeting. The cost would be minimal (i.e. less than N$20 per basket), and providing it works in the way intended, is likely to be highly acceptable to farmers.

[10] Some of the assumptions here are somewhat "heroic", but in making this calculation we seek to specifically answer "detailed task 7" in the terms of reference. The client should use Table 9 as a checklist in carrying out a full feasibility study.

With little hesitation, most farmers said they would pay N$20 per basket if they could protect it in this way - a sum which would easily cover the cost of the plastic which would last for several years. They would recover their investment very fast. Let us assume, conservatively a 6% quantitative saving of their mahangu which is presently being lost. If each basket holds 1 tonne of mahangu, they would save 60 kg per year. Assuming a value of $0.90 per kg, the value of this saving would be $54 per basket used per year. The plastic is paid for several times in the first year it is used.

Where farmers need to increase their storage capacity, or where their baskets are no longer serviceable, one should examine the scope for entirely new storage structures. Various alternatives can be considered, including bins made from galvanised iron, modified water-tanks, fibreglass and plastic containers.

Galvanised iron bins have proved viable for on-farm grain storage around the World, including India, Pakistan, Central America and Swaziland. The viability of the technology has been demonstrated by high and increasing levels of adoption, with small farmers generally paying the full cost, or nearly the fully cost, of the bin. In Central America, farmers are paying around US$60 (N$282) with capacity of 0.8 tonnes of maize - equivalent 1.07 tonnes mahangu, due to the greater density of this grain. The cost may be higher in Nambia, due to high raw material costs, higher transport costs, taxes and labour, but it is unlikely to cost more than about US$100 (N$470)[11], a price which is competitive with baskets of comparable size, and it would provide better protection for the grain. Grain can be fumigated, an important advantage if it is found that the moths enter the grain from the field, and cannot therefore be restrained by lining traditional baskets with plastic.

While the raw material has to be imported, these bins can be made by local tinsmiths, thereby generating a local industry. The tinsmith himself becomes a small businessman, selling the idea to local farmers, procuring raw materials and travelling to the villages to make the bins in situ. With the waste materials, he would make watering cans, buckets etc..

Certain issues will need to be studied in order to assess the viability of the bins under Namibian circumstances:

(a) Quality control. Bins should be made to strict quality norms, with regard to the raw material used, the cutting of material, soldering of joints etc. - this ensures the reputation of the product and encourages adoption by farmers. Central American experience indicates that effective quality control requires that artisans are properly trained, and that the bins they produce be regularly inspected. This is an additional project cost, presumably to be borne by the public purse.

[11] This higher figure is based on a Namibian quote we obtained for 1850 x 925 x 0.5 mm DIN standard material of South African origin, and which proved to be over twice as expensive as similar 0.45 mm guage material currently used in Nicaragua. Even taking account of transport costs, taxes and the thickness of the material, the difference is difficult to explain. Further investigation is needed with a view to identifying cheaper sources.

(b) The need to protect them from moisture and therefore corrosion. They have to be raised off the floor by a flat base of sawn-timber, concrete or other material. They need a roof, but thatched shelters may not prove sufficiently waterproof.

(c) Household removals. Farmers in North-Central Regions move home every five years or so - literally lifting up their palisade-dwellings and setting them down nearby. Attempts to remove loaded bins will probably damage them.

Indeed the bins would need to be thoroughly tested in an entirely new cultural context to those where they have proved so successful.

Plastic containers are already being used by some farmers in the North-Central Regions, and may be considered for wider adoption. However, our initial enquiries suggest that they could only be competitive at very large sizes - retail prices are around N$494 per 2,500 litre capacity FOB Okahandja and N$822 for a 1,000 litre for a 2,500 litre container - equivalent to about N$600 to N$1,000 per tonne of mahangu. One advantage vis a vis galvanised iron bins is that there would be no need to train tinsmiths and organise quality control.

TABLE 10: ESTIMATED CAPITAL COSTS FOR ALTERNATIVE ON-FARM STORAGE STRUCTURES		
Structure	**Estimated capital cost/ tonne of mahangu stored (N$)**	**Observations**
Traditional Mopane basket	333 - 1,000	life about 10 years; unsealable and unfumigable; raw material growing scarcer
Galvanised iron bins	439	price for 1.07 tonne silo; life 10 to 15 years; additional public sector costs in training artisans & quality control
Plastic tanks	600 - 1,000	retail prices for 2,500 and 1,000 litre capacity tank, excluding freight from Okahandja to NCA
* excluding complementary structures such as stands or supports, roofing and shade		

A programme of investigation and trials is recommended to test alternative storage technologies of the kind described above. If they prove successful, they can be demonstrated to farmers, and hopefully, this will lead to large-scale adoption. Government's input will be in the area of R&D, extension, quality control, monitoring adoption and trouble shooting - the seed processing facility at Mahenene might be a suitable centre for this activity - and has already indicated interest.

All other inputs should come from the farmers themselves, who will buy the new materials or structures in local shops or, in the case of metal bins, contract for their supply with local tinsmiths, much as they do now with the Mopane baskets. To maximise adoption, we suggest that subsidisation of these inputs should be avoided, since it will discourage the emergence of private service suppliers. One should try to develop local storage solutions which spread spontaneously, with Government (or NGOs) only supplying technical support.

Improved local storage of grain surpluses is likely to have a very positive impact on food security among the poorest groups. While they will not necessarily acquire the new technology, as they have little produce to store, there will be more grain available locally to buy or borrow from neighbours who do store. Groups of farmers interviewed in a Swiss-funded evaluation of the Central American grain storage project indicated that this had proved to be a major benefit.

With **sorghum**, the best way to address farmers' much voiced concerns is probably to store it on the head. At the household level and with traditional, unimproved varieties, sorghum can be readily stored in this way for a year, with minimal damage - as is done throughout West Africa - though there will be some cost in terms of the larger storage structures. The alternatives are to treat the sorghum with Actellic or some other suitable insecticide, or storing and fumigating it in a sealed container. We are reluctant to recommend storage insecticides, given lack of knowledge of the long-term effects of their usage, the possibility that their use will be banned in Europe and ultimately in Africa as well, and the existence of an alternative technology, i.e. storing on the head.

4.4 Emergency off-farm storage of mahangu in Kavango

In Section 2.3.1, we estimated the storage requirement at 4,000 tonnes. The following options exist:

(a) Use existing Government capacity

Ministry of Works (MoW) and NDC are the principal owners of warehousing capacity in Rundu, but MoW warehouses are currently rented out. At Katji-na-Katji, NDC has a shed with corrugated iron walls and roof, capable of storing 1,250 tonnes. The dimensions of the main building are 27 x 14 x 3.5m, and there is a lean-to of 27 x 4 x 3m. The shed is currently used by one farmer storing approximately 264 tonnes which is badly stacked (with low stacking against walls, no plastic sheeting dunnage) and occupying half the store. If bags are re-stacked, then most of the Katji-na-Katji production surplus could probably be held in this one store as an interim measure.

NDC also has a storage facility in Omega (Caprivi Strip) and this is already being used to store the produce of local farmers. We made similar observations to the local manager about storage arrangements to those made in regard to the Katji-na-Katji store.

(b) Open storage on poles

Where Government land is available, an option would be to use open storage on plinths or pole dunnage under (at least part) canvas sheeting. Based on LFCU costs quoted above, and taking account of the greater density of mahangu vis a vis maize, the initial investment in covers, poles etc. would be about N$28 per tonne. The cost for 2,500 tonnes of mahangu would be about N$70,000.

(c) Rent existing private sector capacity

Private sector storage capacity is at a premium in all the NCA Regions, because of rapidly increasing business opportunities and the expectation, in some parts, of increasing trade with Angola. We were informed that no suitable facilities are available in Rundu (or in Oshakati), but the firm SAKKA Electric offers to construct warehouses with brick walls on their own land and rent out at N$ 11 /m2 /month, increasing by 10% per annum. In order to build it would probably require a two year rental contract. SAKKA says construction could take place immediately and claims that warehouses would be ready for use in six weeks.

A two year contract for rental of a 1,000 sq. m warehouse, sufficient to store 2,500 tonnes, would therefore cost N$132,000 + N$145,200 = N$277,200.

(d) Build a new warehouse

SAKKA also offers to construct 18m span warehouses of any length for approximately N$ 700 to 800 /m2. A 1,000 m2 warehouse with walls of 4.5 m to the eaves could be used to accommodate 2,500 tonnes of mahangu, with grain stacked 18 bags high, and it would cost about N$ 750,000. A cheaper structure could be built using metal walls. In Oshakati we were quoted approximately N$ 655/m2 for 10 m span sheds with metal cladding and concrete floor with a loading of 3.5 tonnes /m2. However, metal cladding would be susceptible to buckling through falling stacks - probably not a good idea if Government is seeking a permanent structure.

The above costs do not take account of land acquisition, access roads, fences or perimeter walls, or any management or engineering services, but they nevertheless permit a rough comparison of the options.

Clearly the best and relatively cost-free option is to use existing Government buildings, where they are available and not required for other purposes, but this will only allow for storage of part of the grain. The rest would probably need to be stored in or close to Rundu, with a view to collecting surpluses to the East and West. Given uncertainties about the future of commercial mahangu production, the least desirable option is to build a new warehouse. Open storage on poles is the cheapest option, and has the major advantage of time, since it can start immediately. The rental agreement with SAKKA would be advantageous in terms of security, which may be a problem in an urban area. While the rental cost for storing 2,500 tonnes is considerable, i.e. N$277,200, compared to $70,000 investment cost for open storage, it might be diminished by sub-letting the building in the second year.

Due to the time factor we recommend pole storage.

NDC is the main party interested in ensuring the physical security of mahangu financed with loans, so we recommend it takes care of the storage operation. The grain will be property of the borrowers, but assuming they are in debt to NDC and Agribank, these two parties can take a lien on the stock. As a condition for refinancing outstanding loans they may also require that borrowers deposit remaining stock with NDC and assign the lenders the right to sell the grain as it sees fit with a view to ensuring repayment. Depositors should be charged for storage at a commercial rate, with a view to setting a precedent which will prove attractive to private operators.

We also suggest Katemo Co-op. participate in the organisation of storage, on behalf of its own members.

4.5 Handling periodic surges of mahangu supplies

Similar arrangements are recommended for storing these occasional surges, firstly to make use of any existing Government or private storage capacity which can be rented, and secondly to store on poles on Government or rented land.

Storage management should be carried out by competent private parties. These may be processors interested in procuring mahangu for their own use, FCEs seeking to market members' mahangu, or specialised storage agents who fit the requirements we listed in the discussion of maize in Caprivi. In line with our earlier discussion, we recommend FCEs organise primarily on a local basis - co-operative marketing should be an initiative undertaken by committed neighbours with a specific business objective in mind.

It should be feasible for co-operatives to invest in storage under such circumstances. In cost-benefit terms, let us assume it costs N$60 per tonne to store the mahangu on poles, including both fixed and working capital costs (as budgeted by LFCU). If we assume an on-farm market price of N$600 per tonne, it should be easy to obtain a premium of 10% or more, simply by bringing the grain together in a location which is accessible to major buyers, e.g. feed-millers from Windhoek. Such buyers will not wish to go round farms picking up a few bags.

As with maize in Caprivi, we do not recommend Government involvement in storage of mahangu, though Government support may be needed in procuring expensive equipment (tarpaulins, fumigation sheets etc.), which could be leased to private operators. Apart from that we recommend that Government concentrates on training of interested parties.

5. THE PROSPECTIVE IMPACT OF A FUTURE SADC FREE MARKET ON THE RECOMMENDED OPTIONS (DETAILED TASK 9)

A SADC free market will result in generally lower, and more unstable prices for maize and maize meal. Price instability results principally from the periodic movement of Southern Africa between a surplus and deficit situation, and consequently from export parity to import parity pricing scenarios.

Underlying the recommendations in this report has been a concern to make farmers more self-reliant and able to survive in a changing environment. Hence we have recommended training of farmers in basic skills, farmer co-operation in addressing local needs, improved on-farm storage, and low-cost and hence sustainable off-farm storage systems.

A SADC free market does not affect our recommendations. We have already taken account of NRC findings concerning the viability of high-input production of mahangu. Lower maize prices will further depress the viability of this activity.

REFERENCES

BERG, E. and KENT, L. (1991) *The Economics of Cereal Banks in the Sahel.* Consultancy report prepared for USAID by Development Associates Inc., Bethesda, Maryland.

COULTER, J.P. and GOLOB, P. (1992) Cereal Market Liberalisation in Tanzania, in: *Food Policy,* December 1992.

DENDY, D. (1993) *Report on a Visit to Namibia to Assist in the Improvement of Pearl Millet Processing and Products at the Namibia Development Corporation, Musese, Kavango.* NRI.

DENDY, D. (1995) *A Study of Millet (Mahangu) Processing in Namibia: The Way Forward.* Consultancy report by Grains After Harvest for MAWRD.

JONES, S. (1992) *Grain Stocking and Storage Strategies for Namibia*, Draft Final Report. Consultancy Report prepared for the National Drought Task Force, MAWRD

KEYLER, S. (1995) Economics of the pearl millet subsector in northern Namibia: a summary of baseline data. ICRISAT Southern and Eastern Africa Region Working Paper 95/03

MALLET, M. and EL OBEID, S. (1997) Feasibility Study for the Marketing of Mahangu by the NNFC. Draft consultancy report to MAWRD and NNFC.

MAWRD (1997) *Food Security or Food Self-Sufficiency for Namibia? The Background and a Review of the Economic Policy Implications.* Discussion Paper No. 1, Division of Agricultural Planning, Directorate of Planning, Department of Agriculture and Rural Development, Windhoek

NAMIBIA RESOURCE CONSULTANTS (1997) *Constraints to the Commercialisation of the Pearl Millet Industry in Namibia.* Final consultancy report to NAB.

STRINGFELLOW, R., COULTER, J., LUCEY, T, MCKONE, C., and HUSSAIN, A. (1997) *Improving the Access of Smallholders to Agricultural Services in Sub-Saharan Africa: Farmer Co-operation and the Role of the Donor Community.* ODI Natural Resource Perspectives, No 20, June 1997. London: ODI.

APPENDIX 1: TERMS OF REFERENCE AND RECORD OF STEERING COMMITTEE MEETING OF 16 SEPTEMBER 1997

ANNEXURE A

TERMS OF REFERENCE

CONSULTANCY ON GRAIN STORAGE FACILITIES IN NORTHERN COMMUNAL NAMIBIA

1. Background

Grains are the main staple food of the majority of Namibians. Domestic grain production is principally rainfed and varies sharply from year-to-year depending on the level and timing of rainfall. In a good growing year, roughly two-thirds of the grain needed to meet human demand is grown domestically. In a poor growing year, this ratio falls to under one-third. Pearl millet (mahangu) is the most important grain in terms of domestic production, accounting for more than one half of national grain output in all years and for well over one half in some years. Between 1991/92 and 1995/96, national mahangu production varied from 15,000 tons to 59,000 tons. Output in the current 1996/97 production year is forecast to be a record, in excess of 100,000 tons.

Well over half of Namibia's total population live in the northern communal areas (NCA). These areas account for almost the entire national output of mahangu. In the populous North/Central Regions and in Kavango Region, mahangu is the main grain and is produced by virtually all farmers. In Caprivi Region, climatic conditions are suited to maize, and in most years a greater volume of maize is produced than mahangu. In all three areas, sorghum is also grown. In Namibia's commercial areas, maize is the only important grain crop. This is produced principally under rainfed conditions in the 'maize triangle' in the Otavi, Tsumeb, Grootfontein area. A small amount of wheat is also grown in the commercial areas under irrigation. Since 1991/92, total grain production in the communal areas has exceeded that in the commercial areas by a factor of from 2 to 5.

Within Namibia as a whole, white maize accounts for about one half of the total quantity of grain consumed directly by the population. The remaining grain consumption comprises principally mahangu and wheat. Wheat consumption, although following a rising trend, is relatively stable from year to year, whereas mahangu consumption varies sharply with the level of domestic production. National mahangu consumption exceeds national wheat consumption in years of high mahangu output, but falls to below it in years of drought.

Mahangu is the preferred staple in North/Central and Kavango Regions. Most mahangu and sorghum produced in these regions is grown on small farms for subsistence. In Kavango Region, additional amounts are produced on Namibia Development Corporation (NDC) farms and under the Farmer Support Programme (FSP). In poor growing years, most farm households produce insufficient mahangu to meet their needs. In such years, the marketed surplus is largely limited to NDC/FSP production and the surpluses of a small number of larger farmers. In good growing years, NDC/FSP production increases and a greater number of farm households produce surpluses over and above their annual consumption. Traditionally, farm households store surpluses in good years to meet deficits in poor years. Thus, off-farm mahangu sales currently are restricted largely to a small number of larger farms and to distress sales by small farm households in urgent need of cash.

2. Objectives

The study will cover the storage of mahangu, maize and sorghum only and will focus mainly on seasonal and inter-year storage.

The main objective of the study is to make recommendations on appropriate types, ownership, management and capacities of off-farm grain storage in the NCA. Specifically, the consultants will determine the most appropriate:

(a) total storage capacity
(b) location(s) of the storage
(c) type(s) of storage
(d) type(s) of grain to be stored
(e) ownership of the storage
(f) ownership of the stored grain
(g) physical management (fumigation, rotation, etc.)
(h) price formation and payment systems for the stored grain
(i) financial and economic costs and benefits
(j) commercial and concessional sources of financing

An additional objective of the study is to assess the need for holding strategic grain reserves in Namibia, and to assess the costs and benefits which would derive from such reserves.

3. Detailed Tasks

1. Project the monthly total (including on-farm) grain storage requirement for mahangu, sorghum and maize in each NCA region taking account of the storage objectives of farm households. Make separate projections for a run of good growing years, a run of poor growing years, and selected sequences of good and bad years.

2. Project and compare the costs and benefits of off-farm storage (a) in bulk in silos and (b) in bags in storage halls. Cost projections should include the costs of construction, maintenance, operation, management and finance.

3. For selected farm sizes, compare the net benefits to farmers of storing on farm with the most efficient means of off-farm storage. Recommend whether Government resources devoted to developing grain storage should be focussed on improving on-farm storage or on developing off-farm storage. Differentiate these recommendations, as necessary, between crops, between regions, and between farm sizes.

4. For off-farm storage, using the findings under 1-3, above, develop recommendations for:

   - the optimal size and location of storage facilities;
   - appropriate ownership and management of these facilities;
   - appropriate ownership of the grain stored;
   - operational procedures for buying and selling;
   - operational procedures for recovering storage costs and for paying for, or returning, grain to farmers.

44

5. Consider the desirability of public subsidisation of off-farm storage, taking account, *inter alia*, of its impact on the development of private warehousing.

6. Recommend means of minimising the possibility of losses by the storage agency, and assess the likelihood of losses being incurred.

7. Assess the financial feasibility of NCA cooperatives investing in storage facilities using finance obtained at Agribank interest rates. Assess the advantages and disadvantages of cooperatives establishing off-farm storage in combination with processing facilities.

8. Comment on the potential role of NDC in grain storage in the NCA.

9. Comment on the impact of a future SADC free market on the recommended options.

10. Assess the need for holding strategic grain reserves in Namibia, the costs and benefits which would derive from such reserves, and the impact of such resources on national and household food security.

11. Throughout the consultancy, draw on the experience of other sub-Saharan countries.

4. Auspices, Funding and Management

1. The consultancy will be undertaken through the Namibian Agronomic Board (NAB) to make use of its experience of maize production, processing and marketing in Caprivi and its experience gained in managing the Mahangu Marketing Intelligence Unit (MMIU).

2. The consultancy will be funded under the MAWRD Capital Development Project "Mahangu Processing". The MAWRD will pay the NAB an invoiced lump sum.

3. A Steering Committee for the work will be appointed, comprising:

   - the General Manager of the Namibian Agronomic Board
   - staff of the Cooperative Division of the Directorate of Planning (DoP)
   - staff of the Marketing, Statistics and Policy and Planning Sub-Divisions of the DoP.
   - representative of the NNFU

4. The consultants will meet the Steering Committee at the start of the study, and liaise with individual committee members during the study, as appropriate.

5. Staffing

The consulting team will comprise an economist who will act as Team Leader (25 working days) and a technical storage specialist (10 working days). Both consultants should have extensive experience of similar work in other Sub-Saharan countries, including experience of work in at least one other country in which millet or sorghum is a major staple crop. The Team Leader should be experienced, in particular, in addressing issues relating to communal and cooperative

45

storage. He/she should also be skilled in quantitative market analysis. The storage specialist should have in-depth knowledge of on-farm and small-scale off-farm storage of millet, sorghum and maize.

46

MINUTES OF STEERING COMMITTEE MEETING: CONSULTANCY ON GRAIN STORAGE FACILITIES

DATE: September 16/1997
VENUE: 30 Hochland Road
TIME: 09:00

1.0 CONSTITUTION OF MEETING

The Chairman welcomed all members to the Steering Committee. A special word of welcome was extended to the consultant Mr J Coulter from Natural Resources International.

2.0 ATTENDANCE

Mr JAH Hoffmann	Namibian Agronomic Board (Chairman)
Mr C Brock	Cooperative Division: DOP
Mr J Coutler	Natural Resources International
Mr M Hishekwa	Marketing Sub-Division: DOP
Ms H Rakow	Statistics Sub-Division: DOP
Ms M Mupotola	Marketing Sub-Division: DOP
Mr Z Uazenga	Namibia National Farmers Union
Ms A Venter	Namibian Agronomic Board
Dr M Westlake	Consultant/Advisor: DOP

3.0 APOLOGIES

Ms P Akwenye
Mr M Fowler

4.0 MATTERS FOR DISCUSSION

4.1 Discussion and amendments to the Terms of Reference of the consultancy.

The Terms of Reference were discussed and the following amendments and additions were agreed upon:

1. **Background**

No amendments were made with regard to the background of the study as set out in point 1.

2. Objectives

- It was noted that on-farm as well as off-farm storage will be addressed;
- This is a baseline study which will assess the viability of grain storage (on-farm and off-farm) either commercialized or as a subsidized facility with an alternative (socio-economic) purpose.
- The economic, financial and institutional viability of off-farm storage will be addressed.

3. Detailed tasks

The following were amended under this point:

1. This point was amended to read: "Estimate total (including on-farm grain storage) mahangu, maize and sorghum expected to be stored in each NCA-region taking account of the storage objectives of farm households. Indicate how storage requirements vary during the year. Make separate projections for a run of good growing years, a run of poor growing years and selected sequences of good and bad years."

2. Not amended. It was noted that point 2 should be compared to point 3.

3. This point was slightly amended as follows: "For selected farm sizes, taking account of institutional and financial viability, compare the net benefits of storing on-farm ...."

   It was noted that the long term viability of off-farm storage largely depends on the creation of regular markets as well as the success of the milling industry and quality of the processed product.

4. The Steering Committee agreed that although the consultant will explore various options with its pro's and con's, it was noted that the consultant will determine the viability of various options and strategies and detailed assessments will only be done on those that proof to be viable. A cost benefit will be done on all options before deciding whether such options are viable. The consultant will only make recommendations according to his professional judgement with regard to institutional, economical and financial viability as well as alternative options for socio-economic benefit.

   Internal supply stabilization will be addressed in annual and bi-annual off as well as on-farm storage within a bad production year.

5. A statement in the consultant's report will cover this point.

48

6. This point was amended to read: "Recommend the means of minimizing the possibility of financial and physical losses by the storage agency, and assess the likelihood of losses being incurred. It was agreed that the on-farm storage in the Caprivi flood plains be addressed as serious losses were experienced recently."

7. This point was amended to read: "Assess the financial and institutional feasibility of NCA cooperatives investing in storage facilities using finance ………………"

8. Point 8 was not amended.

9. This point was amended to read: "Comment on the impact of a future SADC free market on the recommended options especially in the Caprivi area as well as the possible influx of mahangu into the NCA."

10. This point was slightly amended to read: "Assess the need for holding strategic grain reserves (food security) in Namibia, the costs and benefits which would derive from such reserves ….."

11. This point was amended to read: "Throughout the consultancy, draw on the experience of other sub-Saharan countries such as inter alia Mali and Botswana which more or less experience similar conditions as in Namibia."

4. Auspices, funding and management

No amendments were made to this point.

5. Staffing

No amendments were made to this point.

4.2 Determination of applicable dates:

The following dates were agreed upon:

- Commencement date of study: September 16/1997.
- Date of completion of study: October 17/1997.
- Date of submission of draft final report to the Steering Committee: October 17/1997.
- Date of discussion of the final draft report by the Steering Committee: October 22/1997.
- Date of discussion of the final draft report the by the Steering Committee and the Consultant October 23/1997.
- Submission of final report: October 31/1997.

4.3 Any other points of discussion

None.

5.0 CLOSURE

The meeting adjourned at 11:55.

APPENDIX 2: LIST OF PERSONS MET OR CONSULTED

Name	Position
In Windhoek	
Jürgen Hoffmann	Manager, NAB
Christoph Brock	Deputy Director: Co-operatives; Registrar of Co-operatives, MAWRD
Jürgen von Muralt	Management and Training Adviser, Co-op Support Services Project, MAWRD
Sageus Kintinu	Early Warning System, MAWRD
Sheuyange Asser	Early Warning System, MAWRD
Martin Fowler	EU Adviser, Policy & Planning Sub-Division, Directorate of Planning, MAWRD
Michael Westlake	EU Adviser, Marketing Sub-Division, Directorate of Planning, MAWRD
Miss Ndeulita	Head of Food Security and Nutrition Unit, MWARD
Mr Jackobsen	Monitoring and Evaluation, MWARD
Johannes Mesfin	FAO Food Security Adviser, MWARD
Helena Rakow	Statistician, MWARD
Moono Mupotola-Sibongo	Head of Marketing Sub-Division, MAWRD
M. Hishekwa	Marketing Sub-Division, MAWRD
Trevor Uprichard	Agriculturalist/Extension Specialist, RDSP, Katima Mulilo
Mr Kebe	CSB
Michel Mallet	Exec. Director, SA-DC
Rod Davis	NRC
Dr Andrew Sargeant	NRC
Kavango Region	
Peter Horn	Deputy Director, N-E Region, MAWRD
Barry Weightman	Project Manager, RDSP, Rundu
Reino Asindi	MAWRD, Rundu
Boetie Snyman	Branch Manager, Agribank, Rundu
Sikongo Haihambo	NDC Regional Rep., Kavango
Vincent Likoro	FSP Manager, NDC, Rundu
Tinus de Vries	Manager, NDC Centre, Musese
Mr Pereira	SAKKA Engineering, Rundu
Nambase Eliah	Co-ordinator, Kavango Regional Farmers' Union
Julius Hambuyuca	Manager, Katemo Farmers' Co-op.
Pinehas Mukundu	Researcher, KSFR/E
Monica Koshile	Researcher, KSFR/E
Harriet Matsaert	Social Anthropologist, KSFR/E
Hugh Bagnall-Oakeley	KSFR/E, Mashare
Farmers	Shikoro village
Mrs Kamalanga and sons	Katji-na-Katji
Bertha Nangalo	Katji-na-Katji
Mr Katamba	Katji-na-Katji
Caprivi Region	
Wilhelmina Shilongo	Manager, OMEGA Agricultural Project, Caprivi
Mr Sibolile	MWARD, Katima Mulilo
Fred Liseho	Caprivi Regional Representative, NAB
Chief Admin. Officer	LFCU, Katima Mulilo
Shiraz Bhamjee	Kamunu Mills, Katima Mulilo
Mr Machenga and other farmers	Zobue, Kabbe Area, Caprivi Flood-Plain
North-Eastern	

Regions

Mr Imalwa	Deputy Director, NE Regions, MWARD
Didier Helmstetter	Co-ordinator, NNRDP, Ongwediva
Vicky N. Iipinge	Acting CAEO, MAWRD, Ongwediva
N. N. Immanuel	AEO, Ongwediva
W. R. Lechner	CAEO - crops, Mahenene
Ephraim H. Weyulu	CAET, Oshakati
Jack Matanyaire	RSDP, Oshakati
Francois Blanc	Reg. Co-ordinator, NOLIDEP, Oshakati
Paully Iipinge	MMIU, Oshakati
Kalifeni Shatona	MMIU, Oshakati
T. S. Nepunisa	OMAFA Farmers' Co-op., Ohangwena
Julius Ambondo	CAET, Oshakati
Fillemon Amukoto	CAET, Ombalanto
Monika Moses	AET, Uukwaluudhi
Arne Larsen	DCA, Oshakati
Mrs Botha	Intercontinental Supermarkets, Oshakati
The Manager	Punyo Wholesalers, Ondangua
Winsel Potgieter	Maintenance Engineer, ELUWA Wholsesalers, Oshakati
Elizabeth Shivute	Clerk, Continental Wholesalers, Oshakati
Small Mahangu Miller	Ondangua
Emundile Martin	Chief Extension Officer, Ohangwena Region
Various farmers	East Ohangwena Region
Mr Ndjimba and other farmers	Ipembe, Ohangwena Region
Angela Rautia and other farmers	Tsandi, Omusati Region
Reverend Iita	NNFC, Ongwediva

Okahandja

Johannes Cloete	Manager, Profiling Plant, NEC, Okahandja
Johan Muller	Managing Director, Nutrifood, Okahandja
Henry Valentine	Namibia Rotomould (Pty) Ltd

Other

Dr David Dendy	Grains After Harvest, Oxford, UK
David Rohrbach	ICRISAT, Bulawayo

APPENDIX 3: ON-FARM STORAGE OF MAIZE BY FLOOD-PLAIN FARMERS IN CAPRIVI REGION

The following observations are based on a visit to a farm at Zobue, which is on the flood-plain about 20 km north-east from the village of Kebbe. Two other local farmers also joined the discussions.

Flood-plain planting takes place from August to October on the receding flood, and is harvested from January to April, but the area is flooded from April when families leave for higher ground. One or more family members stay on the island to guard and thresh the crop through to September. They try to remove some of the bagged maize by boat, but most leaves by lorry when the flood recedes in October. This means late marketing which was a major disadvantage this year (1997).

Maize becomes heavily infested with the moth *Sitotroga* for the 7 to 10 months while it is held on the islands in the flood plain. This is due to the practice of holding de-husked cobs in large basket weave bins for drying. This moth does not attack threshed maize, since it cannot move easily through a grain bulk. Threshed grain is more commonly infested with the weevil, *Sitophilus*, although little evidence of this infestation was seen in the threshed, bagged maize on the islands at the time of our visit.

Farmers were trying very hard to deliver good quality by selecting only good cobs for threshing, and were willing to apply control measures. We noted stalk borer and mould damage (*Fusarium*) on rejected cobs. Threshing is done using sticks, and breakage was low indicating careful threshing.

Grain is stored in polypropylene bags under a thatched shelter until collected. Heavy losses due to rodents were reported, but this could not be confirmed. Overall weight losses due to insects are unlikely to exceed 1% between harvest and bagging the threshed grain, but without taking account of cobs which are rejected prior to threshing. While the main reason for rejection was cob rot caused by *Fusarium*, an unknown percentage was rejected on account of moth infestation.

APPENDIX 4: THE MARKETING OF COMMERCIAL MAHANGU PRODUCTION IN NAMIBIA

This subject has been investigated by Namibia Resource Consultants (NRC) as part of their study of the Mahangu Market Intelligence Unit (MMIU); we have kept close contact with the NRC study, and given the importance of the subject in deciding on storage policy, have ourselves carried out some interviews in the area.

A key issue in the marketing of mahangu outside of the NCA is: (a) whether it has to be sold as a commodity, with price being set on the basis of its weight and content in terms of protein, carbohydrates etc., or; (b) whether it can be marketed at a premium on account of taste preference, specific functional properties of use in food manufacture (e.g. of weaning foods), perceived health-giving attributes, brand loyalty or any other factor which distinguishes it from competing cereals, particularly white maize.

Mahangu meal has been sold by NDC since 1994, but this scarcely documented experience does not adequately answer this question. There is consequently much uncertainty about the following subjects:

- The potential size of the market for mahangu meal: Is it 1,000 tonnes per annum or 20,000 tonnes per annum?
- The price at which it can be sold. NDC reports that it can normally bear a premium of about 10% vis a vis maize meal. To which type of maize meal are they comparing?

(a) sifted maize meal - retail Windhoek;	approx. \$1.94 per kg in Windhoek for a 10/12.5kg bag
(b) unsifted maize meal - retail Windhoek;	approx. \$1.50 per kg for a 10/12.5 kg bag
(c) unsifted maize meal for the catering trade, delivered to institutions all over the country, or;	\$1.25 per kg for 50 kg bags
(d) "straight-run", i.e. unrefined, maize meal - retail (Punyu)	\$1.25-\$1.36 per kg Ondangua, depending on bag size

- If mahangu meal can be sold at a premium to maize meal, how much can be sold at different premiums? It is unlikely that all customers will stop purchasing when the magic 10% figure is passed, but that there will be a gradual reduction of demand as price is increased. For a well-marketed product, there may still be significant demand when the meal costs 50% more than sifted maize meal. Given that it costs much more to produce mahangu than maize, it is important to estimate demand elasticity.
- Appearance and flavour. There are widespread anecdotal reports that mechanically processed mahangu meal from NDC Musese is not as acceptable as traditionally processed mahangu. However taste panel work quoted by Dendy (1995) suggests the opposite. Are consumers simply reacting to the gun-metal grey appearance of meal produced from Okashana 1, or expressing a real taste preference for traditional varieties?

Can a more acceptable product be produced with Okashana 1, e.g. by bleaching?
- Shelf life. There are reports of NDC products being returned by customers on account of deterioration after 6 months, but there are no clear guidelines concerning sell-by dates.
- Processing costs. Dehulling machines used by NDC have very low capacity. Can they be scaled up to produce a continuous operation? If not what is the implication for production costs vis a vis processing of competing cereals?

If NDC had treated the Musese processing facility as a pilot plant, and had sought to test-market mahangu meal as part of a new product development exercise, much might have been learnt about its marketability. However instead of this experimental approach, mahangu processing enterprise has been treated as a "going concern". Farmers have been growing mahangu on the basis of an unproven processing operation, both with regard to the economics and the marketability of the product.

There is strong evidence, for example from studies by Keyler (1995), that a large part of the Namibian population prefers mahangu to maize meal, and this suggests that a well marketed product could be sold at a premium to Top Score maize meal, possibly at a premium well in excess of 10%. It is even possible that with careful marketing new consumers can be won over from groups who do not traditionally consume mahangu. However given the uncertainties mentioned above, this preference does not automatically translate into consumer acceptance and sales of thousands of tonnes at the retail level.

All that can be said with relative certainty is that mahangu can be sold as a commodity in competition with maize. According to NRC, mahangu could probably be sold for animal feed at prices in the range of N$650 to N$770/tonne ex-warehouse Oshakati or Rundu. Under existing tender procedures, Mahangu meal could probably be sold for institutional feeding in straight competition with maize, at a price of around N$1,250/tonne delivered to institutions around the country - given processing and distribution costs, this may not prove more attractive than sale in unprocessed form as animal feed.

Public support for research on mahangu processing and marketing can be considered principally on the grounds of its benefits to consumers, given that it promisses to answer a need which is currently not being fulfilled by the market, i.e. regular availability of mahangu products on grocery shelves thoughout the country. Such research can also create an additional outlet for Namibian mahangu produced in Namibia, and absorb periodic farm surpluses. The development of popular mahangu consumer products is not only of interest to Namibia but also to neighbouring countries which have mahangu consuming populations, but where mahangu consumption has declined in relation to maize.

Government may therefore consider continuing the process of product development and market testing started by Dendy (1993 and 1995), with a view to: (a) overcoming the above uncertainties; (b) positioning mahangu meal and added value products in such a way as to maximise unit sales revenue. Products would need to be advertised so as to ensure their permanent presence on grocery shelves. However, to do this requires the involvement of a company (or companies) with skills in the development and marketing fast-moving consumer goods (FMCGs) and which already has a large presence in the market[12]. Depending of the company's existing skills, some additional technical assistance might be provided at public expense.

The difficulty with this is that serious FMCG manufacturers or distributors are likely to be detered by uncertainty over raw material supply. Domestic supplies are far too unstable, so in most years they would need to be supplemented by imports, from India, Angola and/or other countries. The scope for finding suitable reasonably priced material (in what is essentially a thin world market) is currently being researched by NRC. Even if such supplies can be procured, Government will need to give assurances about not intervening in the market, for drought relief or other purposes, as this could upset the supply situation and deter manufacturers.

In view of difficulties over raw material supplies, it may prove difficult to create a really large market for mahangu meal in Namibia, i.e. tens of thousands of tonnes per year. Notwitstanding smaller localised markets can be created through the expansion of custom milling in the NCA, and the commercial activities of companies (e.g. ELUWA) who are developing sales in response to domestic supplies and local marketing opportunities.

[12] Namib Mills is an obvious candidate, but there may be other suitable companies producing or distributing other kinds of consumer goods.

APPENDIX 5: SYNOPSIS OF FINDINGS ON FARMER CONTROLLED ENTERPRISES

Since the latter 1980s, co-operatives and similar group enterprises, which we collectively describe as *Farmer-Controlled Enterprises* (or FCEs), have been widely promoted by donors and NGOs all over Africa, as a response to the problems and challenges posed by market liberalisation. In principle this movement has been purely voluntary, but in reality sponsors have frequently made the belonging to an FCE a pre-condition to obtaining concessional resources under donor-funded projects.

Recently NRI and the Plunkett Foundation were jointly commissioned by ODA (now DFID) to review these experiences and draw conclusions about factors leading to success or failure of FCEs in Africa. Following a desk-work phase, research was carried out in five countries, including Ghana, Uganda, Zimbabwe, Mali and Burkina Faso, and involved a review of the FCE sector and case studies of 19 specific enterprises - see Stringfellow *et al,* 1997.

The main finding emerging from this study was that donors were frequently promoting organisations which were too complex to be effectively managed, given current group management skills. As a consequence they frequently did not last long, and at times, members' negative experiences were contributing to undermining future co-operative initiatives. Processing operations, involving the joint operation of equipment were particularly prone to failure.

Success in FCEs tended to be associated with:

- small, homogeneous, village groups with clear member-driven agendas, and where members have frequent face-to-face interaction
- simple marketing or procurement activities in which they can achieve rapid success, and where they have a comparative advantage vis a vis other suppliers of these services.

Rather than federating vertically on co-operative lines, successful groups were tending to link directly with private service suppliers in the outside world. This does not rule out regional entities or federations, but it suggests that such organisations can only be as strong as their component parts. This all points to the need for small-scale and simplicity, and working from the grass-roots upwards.

APPENDIX 6: NOTES ON MAINTENANCE, OPERATION, MANAGEMENT OF STORAGE STRUCTURES

Maintenance

Maintenance costs for sheds will be minimal in the first three years of operation. The condition of warehouse facilities seen in the NCA Regions indicates that the structures are likely to have a longer than average life-span in the very dry climate. The most important factor is to ensure that bag stacks do not lean against the walls of the storage structure causing cracking in the case of concrete cladding and buckling in metal structures. Lorries should not be allowed to enter warehouses for loading and unloading since doors and walls are quickly destroyed.

Maintenance for open storage involves the annual replacement of plastic sheeting for the stack bases and replacement of canvas tarpaulins every three years.

Operation

Operating costs will be a function of the staff requirement for each facility. Since the most appropriate location for assembly point warehousing is in the production areas these will be small stores of 2,000 to 3,000 tonne capacity. NAB is currently renting storage facilities in Katima Mulilo and management costs are estimated at N$ 19 / tonne (for seasonal storage) to include preparation of the yard, intake labour costs, security and insurance, losses, out-loading and supervisory staff. This seems to be a reasonable estimate for operational costs for the NCA Regions.

Management

Effective storage management requires that:

- the site and facilities to be used are fit for the purpose;
- goods to be stored should be fit for storage;
- the period of storage should be controlled if possible;
- storage (intake) should be orderly and recorded;
- quality should be maintained sufficiently for the intended use;
- there should be security against theft and other losses;
- any losses of quality or quantity which nevertheless occur should be identifiable and accountable;
- discharge from storage should be timely, orderly and recorded;
- the goods discharged should be in a form appropriate to the intended use.

These requirements relate to general, essential principles. From them may be derived particular working rules. Essential principles are appropriate to all situations and circumstances, while working rules relate to particular situations and should be applied only as far as necessary in the actual circumstances.
For example, "first-in first-out" is a useful working rule in storage, but it should not be rigidly applied in situations where there are sensible and acceptable

reasons for discharging goods on a more flexible basis. The essential principles are that discharge should be orderly and recorded and that the goods discharged should be satisfactory for the intended use.

Scientific storage management requires scientific knowledge to be combined with the common sense approach. Good storage management, requires only that commodities are kept sufficiently dry, to prevent mould damage; sufficiently cool, to prevent serious damage by insects and mites; and sufficiently secure against theft and rodent damage. In some climates, these precautions are all that is necessary. However, in tropical climates the mean ambient temperature is generally favourable to insects and mites and it is often impossible or impractical to keep large stocks of cereal grains at a temperature low enough to prevent the multiplication of these pests. Therefore, if losses in quality and quantity are to be prevented, supplementary measures become essential.

Fumigation

The appropriate fumigant to be used is phosphine formulated under a number of trade names (Phostoxin, Celphos, etc.). Bagged grain in stacks is treated under gas proof fumigation sheets held tightly to the ground using sand snakes (note that plastic ground sheets must be used where the stack is not built on a concrete floor. This is particularly important on the sandy soils of the NCA Regions. Phosphine is applied at the rate of 1.5 gm per tonne for a 5 day exposure period. Approximate fumigant costs are N$0.25 / tonne of grain. NAB estimate their application costs at around N$6.00 /tonne to include the fumigant. For maize and red sorghum, it is recommended that fumigation should take place every 4 months. With mahangu a 6 month interval is likely to be adequate, although this should be checked by regular inspection to look for moth webbing on stack surfaces which indicates infestation by the moth *Corcyra cephalonica* which is endemic in the NCA Regions.

APPENDIX 7: POINTS TO TAKE INTO ACCOUNT WHEN CONSTRUCTING A GRAIN STORAGE WAREHOUSE

Though a grain storage warehouse may superficially appear similar to large industrial storage buildings, there are many features of design detailing which make it distinctly different. These features are described in this annex. It must keep grain DRY, CLEAN, PEST-FREE, SECURE and SAFE, and FACILITATE HANDLING.

Grain is a biological product. It contains water and can absorb or desorb water (moisture) if external conditions allow it. High moisture content encourages germination and damage by bacteria, fungi and insects. These cause weight losses and reduce the nutritional value of the grain. If grain is kept at a certain moisture content, it can be safely stored for a long time - at low moisture contents it can be stored for years. For long term storage in Namibia the maximum allowable moisture content is 13 percent. Grain can absorb moisture in vapour and liquid forms. Water vapour will be absorbed slowly from humid air, liquid water is absorbed more rapidly. Sources of water include capillary water rising through a floor slab, flooding of the floor surface from heavy rains, wind-blown rain spray and rain-water leaks. Each of these sources of water must be systematically controlled by positive design features.

Choose a suitable elevated site. This will keep out water from adjoining land; install a drainage network of adequate size, capacity and extent; and arrange for rapid disposal of collected water.

Examine each site individually, during the rainy season, before design begins. Supplement direct observations and measurements by obtaining data from a meteorological station and by questioning local residents on the problems of the site. Design to prevent leaks in roof cladding and the drainage system. Specify strong or thick structural materials which will last for 20+ years without replacement and with low needs for maintenance. Ensure that collected water can flow away freely by designing appropriately dimensioned and angled gutters, intersections, and overall roof pitches.

Roof pitch should be at least 15° to the horizontal unless there is local proof that flatter pitches can be rain-tight with normal workmanship. The normal or commonest roofing material is galvanised steel with corrugated or other profiles. Sheet runs should be as long as practicable for transport, since longer sheets reduce the number of end laps and the potential leaks. For corrugated sheets the minimum overlap at sheet ends is 150mm; at edges, two full corrugations (about 150mm). The correct sealing of the edges of the sheets and the roof bolts is important. The correct number of bolts per sheet is also very important. If there are too few, the sheets may rip due to the wind catching under the edges.

A roof overhang of about 1m is necessary to shade the ventilators underneath. In areas of low rainfall, such as in Namibia, this allows gutters and downpipes to be omitted entirely and roof water simply spills onto a pavement or into a ditch below.

Prevent rising damp by incorporating a waterproof membrane in or under the floorslab. The membrane may only be omitted in zones of very low rainfall-say 200mm or less per year. The membrane's purpose is to block the rise of groundwater through capillary pores in the concrete, its subbase and the soil underneath. It should not be assumed that open layers of selected hardcore material would be sufficient to disrupt this capillary action. The membrane can be a continuous layer of bitumen or asphalt sprayed onto a sub-layer of lean concrete; or a polythene sheet (minimum 1000 gauge) laid on a smooth layer of sand above blinded hardcore. Instruct construction workers to be careful to avoid puncturing the membrane when subsequently laying reinforcing steel and concrete on top of it.

To discourage saturation of the floor subbase and walls, set floor level at least 150mm, and preferably 300mm, above surrounding ground or roadway level. Greater relative elevations, while convenient for loading trucks with grain in some circumstances, are not economically justified, and risk problems with settlement of hardcore and floor cracks; install an external pavement 0.75m to 1.00m wide around the external perimeter of the wall, below floor level, with drainage channels or ditches at its outer lip and seal the pavement to wall and channel with cement mortar.

Economical walls may be made of hollow concrete blocks or of metal sheeting. To limit block panels to 25m^2, horizontal load-bearing beams have to be inserted. This adds considerably to the cost of the blockwork, and makes metal sheeting more competitive. Concrete blocks will absorb rain on their outer surface. This must not be permitted to soak freely through to the interior of the warehouse. To inhibit such spread of dampness, either specify high-density concrete blocks which possess a close surface texture; or point all mortar courses flush externally and internally, and seal the faces with a thin coat of cement-lime rendering or a sprayed slurry of cement-lime-sand or a thick and waterproof cementitious paint. Walls clad with steel sheeting should have sheets overlapping by one corrugation at sides and 100mm at sheet ends. Corrugations normally are fitted vertically. Run the lowest row of sheets outside the lower wall or ground beam, so that water will be shed cleanly. Do not embed the sheet end in a fillet of cement mortar, because this creates a galvanic corrosion cell which rapidly ruins the metal. Any contact between metal sheeting and concrete must always be blocked with inert paint or bitumen.

Ventilators are needed to remove humid air from the warehouse interior and to reduce the temperature for better working and storage conditions. The objective is most economically attained by locating screened apertures close under the eaves. This develops natural air currents which flush out stale and humid air particularly from the upper portions of the building, where it tends to accumulate due to convection. Ventilators need to be screened against birds and rodents. If they are long and narrow, and kept very close to the roof, entry of wind-driven rain is not likely to be a problem. The lower edge of the ventilator aperture should be no more than 1m below the wall/roof intersection, and preferably less, to discourage entry of rain-drops and spray, and strong sunlight. Aperture width depends on climate and wall type. As a starting point, width is commonly half of the bay width. Increase the aperture width to full bay width in very hot or humid zones, or in stores with metal walls. The aperture tends to be reduced in windy zones and cool, dry zones, or with high walls of masonry or concrete block, but not to less than a 1/4 of the bay width. In end bays, stop the aperture 2m from the corner of the building, to prevent turbulent winds blowing rain in. Screen all apertures with mesh of woven wire or cut and stretched plate (2mm wire woven to form squares of 15mm or slightly smaller). Secure mesh to frame with thin strips of plate. Do not use fine 'insect-proof' mesh, because this clogs easily and ruptures when someone tries to clean it.

Design for a clean environment

The warehouse is used to store valuable food commodities. No one likes food which has been carelessly mixed with foreign matter, or tastes and smells bad because of exposure to damp, or has been poisoned with pest excreta and chemicals. Some contaminant even make the food unfit for human consumption e.g. engine oil and accidently high-levels of chemicals used for pest control.

Poorly designed floors are a frequent source of dust. Dust arises from weak or badly-cured surfaces, from cracks, or gathers in open joints. A well designed floor eliminates these dust sources, and is easy to sweep clean. Avoid placing a screed on top of the main structural slab. Screeds soon crack away, leaving ugly, dusty areas. Ensure that the slab and its surface are totally homogeneous and dense. Control the water content so that weak laitance (cement milk) does not bleed to the top during compaction. Use a heavy tamping beam as well as a poker vibrator, to obtain good compaction right through the whole depth of the slab. Trowel the surface firmly, using a rectangular wooden trowel, after the tamping beam has passed. This will yield a firm level surface. To smooth the surface, skim once or twice with a steel trowel initially and after the concrete has set for an hour or two. Finally, ensure that the new slab is properly covered and left undisturbed to cure. Minimise the number of joints in a floor slab. Carefully detail expansion joints, contraction joints and day-work joints. Pack the lower portion of a joint with a compressible filler (e.g., bitumen-impregnated chipboard) and fill the top 50mm with a stiff well-tamped mastic. To prevent cracks developing in the floor, close attention must be paid to subbase compaction using a hand-steered vibrating roller close to walls as well as a heavy non-vibrating roller across the main width of the floor. Sub-layers of selected gravelly fill material should be rolled in layers not more than 250mm thick. Telford-type stone hardcore must be strong, and set vertically before packing stones are hammered between them. Then spread a blinding coat of fine crushed stone chips and roll again, moistening as necessary to get good compaction. To prevent surface cracking reinforcement can be placed 50mm below the top surface.

Proper casting and curing of all concrete surfaces goes a long way to controlling dustiness. In wall panels of concrete blocks, strike all mortar courses flush with the blocks' face (grooved courses inhibit drying after rain). Seal all porous-textured faces, to remove insect refuges and dust traps, as well as to control wetting and dirt retention. Cracks, which are dust sources and insect refuges, show up best against a light-coloured surface finish. Cementitious paints are the most durable, followed by 'plastic' water-based emulsions. Even limewash can be effective but it is relatively short-lived. Cream tints are the most suitable colour. Try to get a neutral pH in the surface finish, e.g. by adding salt to limewash, and consult manufacturers for other types. A lower pH helps pest-control sprays' effectiveness and longevity, because the sprays are slightly acidic and early applications become neutralised when in contact with high alkaline cement concrete. Smooth surfaces reduce the amount of spray chemical required for pest-control throughout the operational life of the warehouse. Smooth surfaces are also easy to brush clean of dust.

If sliding doors are used the guide rails or channels can be difficult to keep clean. An upstanding lower rail is easier to clean than a sunken groove or channel in the threshold. It is best located externally, where wind and rain tend to clean it. If a sunken groove is chosen, then make it wide enough to contain the whole thickness of the door, and deep enough to be free draining and easily brushed out. Again, external location is better, with open ends for draining away any water that may get into it. If a groove has to be situated inside the doorway, taper up the ends so that dust can be swept out easily.

Trucks and other vehicles carry dirt into the warehouse on wheels and bodywork. Drivers may perform minor repairs and leave rubbish lying about. Heavy wheel loadings soon damage the best of floors. To control these nuisances, vehicles should not drive into the warehouse. Step the threshold, lower the lintel, or bolt a steel bar across a high doorway. Do not use barriers which would obstruct foot traffic.

All trees within 20m of the warehouse should be cut down or at least topped. This will decrease the nuisance from fallen leaves (which block roof drainage) and birds (by discouraging roosting). Minimize horizontal ledges and other dust traps, particularly the frames of roof and doors. As far as possible, make surfaces smooth and inclined, and interior surfaces easy to brush clean.

Pest infestation in all buildings can cause risks to human health, economic degradation of the contents, fire hazard and structural deterioration. Grain stores are specially prone to infestation because they contain foodstuffs which are very attractive to certain common pests. The rodent family includes rats and mice which can survive in a variety of environments, but some situations encourage rodents more than others. Rats need to drink water, but mice can survive on the moisture contained in the foodgrain. Infestation pressure may be seasonal. When there is plenty of food in the fields around the store, rodents may not seek to enter; but when this food source diminishes, the store and its contents are attacked persistently. Rodents are adept at burrowing, at climbing and at squeezing through small gaps. Once inside the warehouse they breed prolifically. They destroy sacks, consume large quantities of grain and excrete over even larger quantities. This gives grain an unattractive visual appearance and an unpleasant taste and smell. Rodents carry parasites, bacteria and virus diseases, which harm human health, in some cases fatally. Rodents may damage both structural fabric and fittings. They have to gnaw or chew at hard materials in order to keep their ever-growing teeth ground down. They shred soft materials to make nests. This can cause serious damage to electrical fittings and cables, to water pipes and to timber furnishings, with subsequent dangers to humans and the stored commodity. Their burrowing activity can lead to localised subsidence. Rats (not mice) will burrow for great distances horizontally in loose soil and along drains, but seldom dig deeper than 750mm. Both rats and mice are excellent climbers. Rats have been observed to climb 6 courses of concrete blocks and mice 9 courses of smooth-faced bricks, using the mortar courses as a ladder. Both pests use corners, pipes and carelessly-strewn sticks to climb higher. Mice and young rats can squeeze through holes as small as 7mm in diameter. Where cables and pipes run through a wall, there is often a weak spot which rodents can scrape out to obtain entry. Some rats swim well and enter building through drains, sewers and W.C. pans.

Birds can cause direct economic loss by consuming grain. They also cause damage indirectly. Their nests block gutters and downpipes, leading to water damage and their droppings encourage the growth of fungi on various surfaces. Birds carry parasitic insects, and sometimes pathogenic bacteria, which spoil grain and annoy workers. Their excreta and feather droppings are unsightly, spoiling the appearance of sacks, grain and building surfaces. Birds seek roosting and nesting places in or on buildings and nearby trees. But they find it difficult to perch on smooth, inclined surfaces, and dislike low trees close to traffic and people. The smaller birds can squeeze through holes larger than 13mm.

A relatively small range of insect species become serious pests because they can thrive in unprotected stored grain, but the majority of species are not so well adapted. Once the insect pests are introduced, they can multiply very rapidly. These pests are controlled chiefly by spraying and fumigation using chemicals which, when properly mixed and applied, are highly toxic to the pests, but not harmful to humans consuming the food. Insects and mites can survive in an 'empty' store by taking refuge in dust, dirty floor joints and cracks, porous-textured surfaces and rubbish. This residual infestation carries over into newly arrived grain, followed by an exponential growth in pest numbers and consequent grain damage. All such carry-over refuges must therefore be eliminated by design, careful construction and management and regular maintenance.

Fungi (moulds) and bacteria require a damp environment for survival. Sources of dampness include construction water, condensation from the atmosphere, rising damp in floors and walls, porous wall surfaces, and leaks through roofs, ventilators and doors. Grain brought in for storage will normally be of a moisture content low enough to prevent the growth of fungi and bacteria. But grains must be prevented from absorbing moisture during its storage period and the best way is to keep the interior of the building and the stored grain scrupulously dry. Before any species can infest a building, individuals must first enter. They will survive only if the temperature and humidity are suitable and if prophylactic chemical poisoning has been omitted. Infestation can build up when they find adequate food and water, shelter, nest sites and nesting material. Physical measures to prevent infestation by fungi and bacteria depend upon excluding liquid water and dampness.

If foundations do not rest on bedrock, then rodents will be excluded if the foundations extend 900mm deep, or have an L-shaped curtain wall 600mm deep with a 300mm projection outwards from the line. No breach in the foundations may be larger than about 9mm which is sufficient to prevent rats squeezing through. Masonry sub-walls should be well pointed below ground level and plastered with cement-sand render on the outer side from 100mm below final ground level to 800mm above. Termites are excluded by poisoning the floor subbase, the grade beams, and a strip of soil about 300mm wide by 300mm deep around the outside of the building. The highly toxic and peristant chemicals Aldrin, Dieldrin and Chlordane are necessary. Cracked concrete, gaping joints, and floors of beaten earth or asphalt are an open invitation to all kinds of pest. Floors must therefore be of dense concrete, completely covering the area between the containing walls, with carefully constructed joints. Proper reinforcement of the slab strips, allied with thorough compaction of sub-base and base layers, is essential.

Aim to prevent rodent access to the upper parts of walls. Stop rodents climbing up the walls by ensuring that blockwork has smooth faces, by striking mortar joints flush, by sealing around cables and pipes with cement mortar (admixture of 20 percent crushed glass gives added deterrence) for the full thickness of the wall, by grills on downpipes mouths, by using stand-off brackets for downpipes, and by eliminating nearby jumping points. To control rodents access in the lower 1m of wall, ensure that: foundations are rat proof; and there are no holes larger than 6mm on the external and the interior faces of the above-ground wall. Pay particular attention to the joint between column and blockwork panels. Seal cavities in hollow blocks to prevent both rodents and birds making use of them. Plaster or gloss paint the lower 800mm of wall above ground or pavement level. For walls clad with metal sheets, paint the outer face of the grade beam with smooth (slippery) bitumen, set the sheets tight against the beam face, and block the corrugations with contoured strips of metal or hardwood fastened to the top face of the grade beam inside.

Doors and doorways are the most vulnerable point in defence against rodents and birds. Along the bottom and sides of doorways, ensure that gaps are 6mm or less, to exclude rodents. On heavy sliding doors the top suspension rail may be expected to sag. This will mean that the door eventually scrapes the threshold, causing difficulty when opened and closed. Adjustable hangers are needed. Pay special attention to the lower corners of the door and the guide rail or groove, so that these have no gap larger than 6mm when the door is closed. Where pairs of doors abut when closed, fit an overlapping lip to seal the interface to less than 6mm, for the full height of the door. Any doors made of wood should be faced with metal sheet along the bottom, to a height of not less than 300mm, to prevent rodents chewing at them. Wooden doorposts should be similarly protected. Fit any small doors in the warehouse with self-closing springs, to reduce the risk of rodent entry if the door is left open and unattended. Around the top of the door, ensure that gaps are 12mm or less. Fit a sloping hood above the rail of a sliding door, to discourage birds from roosting, and fit the end of the hood snugly to the rail. Cover any offset between rail and lintel beam with metal strips.

Eliminate bird perches as far as possible. Incline unavoidable ledges at 45° or steeper. Fit screens flush with the external face of the wall. Reduce all gaps at eaves to 12mm or less. Contoured metal strips, profiled to match the corrugations of the roof sheets, can be fitted into the underside of the sheets and fastened to the wall-plate or adjacent purlin. The practice of stuffing the gaps with mortar works only if the mortar is firm and carefully packed into the gaps for the full thickness of the wall, and if the parts of the sheets touched by mortar have been previously coated with bitumen paint to prevent the cement corroding the metal. Carelessly packed mortar is soon dislodged by thermal and wind stresses on the roof sheets. Tight sealing is required at the ridge cap to exclude rain, this will also exclude birds.

Pipes, cables, drains and ducts should be carefully built into the wall and sealed in a manner that excludes rodents. Pipework runs should allow for differential settlement of the wall and adjacent materials, so that the pipe will not be broken or its sealing to the wall disrupted. Avoid any external projections at fittings that might help rodents to climb the wall. Projecting skirts may be necessary around pipes and cable conduits. The lower 600mm of rainwater downpipes can be enclosed in smooth-rounded concrete shrouds. Block pipe mouths with grills (clearance between bars 6mm or less) which can be removed for maintenance.

Rats and birds need to drink water. Therefore open water, e.g. in tanks or drains, should be avoided as far as possible. Design ditches and their outfalls to empty out completely. Cover tanks, manholes and inspection chambers with close-fitting vermin-proof lids, but ensure that these can be removed for maintenance and replaced without loss of effectiveness. General rubbish and garbage provides a food supply and shelter for all types of pest. It is best to burn garbage and then bury it. At the warehouses and other buildings provide steel buckets and dustbins with lids, to encourage people to be tidy.

During construction, keep the site as clean and tidy as possible. Destroy any termite creations on site, and spray the bases and adjacent land of new buildings with termite poison. After fresh concrete has had its curing period, ventilate new buildings thoroughly. This removes dampness, and prevents the growth of fungus on plaster and furnishings. When finally clearing up the site, plant bare areas with a creeping, low profile grass. The grass roots will control erosion, and the grass's low stature will not provide shelter for rodents. Trees are decorative, provide pleasant shade for workers and can help to keep the subbases of the roadways drained and firm, but specify trees which will not grow taller than the warehouse walls or else of a type which can be cut back frequently (like Eucalyptus). Do not plant trees so close to the walls that they would provide jumping points for rodents, or that their roots will disturb foundations.

Losses

Physical losses of grain can arise from theft by humans and from consumption by large and small animals. Human thieves and large animals - cows, sheep, goats - require strong physical barriers to keep them out. The first defence is a strong, high (about 2.5 m) fence around the site, with similar well-fitting gates. Flood-lighting of site and buildings exteriors is worthwhile in high-risk neighbourhoods.

At the warehouse structure itself, and also at the office and the store-rooms, design doors to be strong, tight fitting and lockable. The keys for mortise locks tend to get lost, so for the warehouse door it is better to padlock the door externally. If the keys are lost, it is possible to saw off the padlock without damaging the door. The tongues of brackets for the padlock should have over-dimensioned, elongated holes to accommodate slight wear and sag in the door suspension. Each warehouse door should be locked from the outside, to avoid opening other doors needlessly when working at only one doorway.

Ventilation apertures should be high up in the wall, which makes them inherently difficult for a thief to gain access. In lower ancillary buildings, the windows or ventilators should be fitted with external bars or grilles through which a boy cannot squeeze, and sufficiently strong to resist a strong man.

Another source of loss is spillage from torn sacks. Apart from rough handling, sacks can be torn by sharp corners or snags which may occur at doorways and low-level fittings. Such protrusions can also cause injury to people. Therefore make all likely corners, edges and other protrusions and surfaces smooth and rounded. Provide concrete aprons outside doorways, where trucks will stand, so that any spillage from burst sacks can readily swept up without collecting dust and dirt.

Electrical wiring and fittings can cause fires or serious injury if they malfunction. Ensure that all electric parts are heavy duty, properly earthed, securely fixed, and sealed against ingress of water vapour, ignitable dust, insects, rodents and birds. External lamps need special attention to discourage birds from perching and fouling them.

Choose the number, location and dimensions of doorways and doors which will make labour-intensive grain handling as convenient as possible at reasonable cost. Door size and location is constrained by the number and size of the bays and it will often be economic to let the door be the full width of the bay. The minimum door size should not be less than 2 m high by 3 m wide (up to, say, 6 m wide). The height may be increased as convenient to meet the lower edge of the ventilators, or to suit the position of an intermediate beam that can serve as a lintel. For doors that are to be over 2.8m high, ensure that trucks are barred from entering. If the orientation of the store's major axis is east-west, the long sides will be subjected to less sunshine than the narrower sides but the prevailing wind should be taken into account. If the long side is perpendicular to the prevailing wind the amount of ventilation will increase causing a decrease in temperature. Doors in the long sides reduce carrying distances and make better use of floor space. They also reduce roadway requirements on some site configurations. In large stores, double-leaf, sliding doors are the most practicable, since the alternatives of hinged or roller doors have a higher maintenance requirement. Small, single-person doors are not required, they serve no useful purpose which is not already provided by the large main doors. Fit doors externally and ensure that handles are permanently fixed in positions which cannot damage doorposts when the doors are opened. Locate stoppers on both the top and bottom guides of sliding doors to limit door travel. Any hinged doors should be fitted with stoppers and hooks to hold them in position against wind. Outside the doorway, design a concrete platform or loading dock, with dimensions to suit the movements of labourers and trucks. Fit its outer lip with a wooden fender or bump-bar to stop trucks breaking the concrete. Above the doorway, provide a cantilevered canopy externally. This shades the doorway and workers from strong sunshine and from rain. The canopy should protrude sufficiently to cover the largest of trucks. If the canopy cannot be fully cantilevered but has to be supported by posts, keep the posts well back from where the truck will come, to prevent the post from accidental damage.

All along the truck approach and departure lanes, install rocks or concrete bollards to keep vehicles away from the walls and drains channels, but guiding the vehicles in toward the loading dock.

Avoid irregular floor surfaces and as far as possible, avoid steps within the warehouse. They are a nuisance and a potential danger to foot traffic. Differential settlement of sections of the floor slab can endanger stack stability, as well as being a danger to workers where slab edges stick up. This is yet another reason for ensuring that floor bases are well compacted. At joints between sections of the slab, provide tie rods, lubricated for half their length, across contraction joints. This will permit horizontal movement but prevent differential vertical movement. The long-strip method of casting floor slabs is preferable to the chequerboard pattern, because the long-strip method minimises the number of joints and zones of potential differential settlement. It is also quicker and more economical to construct.

Maintenance

Maintenance is the work involved in keeping a building or pieces of equipment in good condition so that it continues to perform its function adequately. Maintenance protects the stored commodity, by preventing defects which would cause or contribute to deterioration or damage. All maintenance work aims at preventing defects from occurring. Storage costs are reduced by appropriate preventive maintenance. It is too late to repair if the produce has already been damaged due to a fault in the roof.

Preventive maintenance includes minor repairs and replacement of small components, with emphasis on prevention of serious defects and emergency conditions. The work is usually performed by a mobile, permanent team of maintenance technicians, with skills in all the common building and mechanical trades. Occasionally they may be supplemented by specialist technicians on short contracts for specific jobs. Major repairs can also be included in maintenance. However, for a well-maintained structure, major repairs imply some defect that normal maintenance intentionally did not cover. Large jobs are usually put out to contract, because they tend to overload the resources of the normal maintenance team. A planned maintenance programme is the best way to organize work on a storage building, storage site or piece of associated equipment. Planned maintenance saves costs, because major damage to structure and stock is prevented. A systematic plan ensures that no element is forgotten. Management can be smoothly organized, to avoid the worst of peak demands on maintenance staff. The Planned Maintenance Programme has three basic elements. Regular pre-planned inspection of each building, each site and each piece of equipment. During the inspection both potential defects and any actual damage or wear are recorded. Prompt execution of necessary repairs, replacements and servicing, according to set standards. Supervision to ensure that maintenance jobs have been performed in accordance with desired standards and within an agreed schedule. Planned Maintenance should begin as soon as a new building, site or piece of equipment is taken over and should then continue throughout its useful life.

APPENDIX 8: NOTES ON OPEN STORAGE ON POLES

Points of immediate relevance in Caprivi

Plastic sheeting of 500 gauge should be used for the base of each stack (to prevent escape of fumigant gas through the sand) and the poles used for dunnage should be of regular size and shape (Eucalyptus poles are suitable). The stacks can be built to at least 10 to 15 bags high at the eaves and bags above this level should then be angled to a peak to allow rainwater run-off.

Rain water protection should be provided by canvas tarpaulins to prevent excessive heating and moisture relocation in the stack, and reduction in grain quality through stackburn and moulding in the top layers. If plastic covered sheets are to be used, these should only be on the walls of the stacks, and should not cover the entire stacks. The proper use of pole and sheet storage can be seen at the Grain Marketing Board (GMB) in Zimbabwe. Suitable canvas sheets can be imported from South Africa and Zimbabwe, and they should be in place by the beginning of the rains and be firmly roped.

Making a 5,000 tonne maize stack - as practised at GMB

The stack is 18 m wide by 54 m long and contains 100,000 x 50 kg bags. It must be sited, wherever possible, on ground with a low water table, adequate runoff and good drainage. Typically it is raised on cambered, well-consolidated earth areas with ditchdrains around. Nearby terminte nests must be destroyed.

Old tarpaulins are used for groundsheeting, or plastic sheeting is used. In addition to providing a gas proof barrier, this facilitates clean recovery of any loose grain which may be spilled when the stack is broken, and protects bare ground from erosion around the edges. In the event that concrete hardstands are used instead of timber dunnage, it prevents ground moisture from rising into the bottom bags.

Where timber dunnage is used, gumpoles are laid over the scrap tarp underlay on earth hardstands to ensure that the bottom bags do not absorb water from the ground or from surface run-off. At least two layers are used because, if the ground becomes waterlogged, a single layer can be submerged. Two metre length gumpoles, with 100 to 150 mm butts, are bound together with wire in the foundation layer. About 1,500 are needed for two layers on an 18 m x 54 m stack base. They are replaced every four years. The ends of the poles are aligned or trimmed so that they do not extend beyond the outer edgers of the bottom layer of bags, and wire ends are tucked away neatly. This ensures that, when fumigation is done, the edges of PVC sheets can be secured close to the base of the stack without being damaged.

It has a ridge about 9 m high, sloping down on each side at an angle of about 21 degrees to eaves which are 6m high. This is to ensure that rain has sufficient run-off. A steeper slope may be difficult to climb, particularly when the top tarpaulins are in position. Stack sides are sloped inwards at an angle of about 8.5 degrees to the vertical to prevent them collapsing outwards.

A level border 0.6 m is provided around the base of each stack so that rolled bottom edges of gasproof sheets can be pressed down on it under sand babs when the stack is fumigated. To withstand any tendency to collapse, stacks are strongly constructed by bonding bags in alternating layers of 'headers' and 'stretchers' at right angles to each other. In alternate layers, two "bonding lines" are laid accross the width of the stack, one stretcher in from the ends of each 18 x 18 m section. All bags are packed tightly together with their ends overlapping. The outer bags are positioned carefully, using stretched twine as a guide.

Efficient bag handling and good stack-building require experience and good supervision. Between 9 and 14 labourers working under a stackmaster can build a 5,000 tonne stack in about seven days. The first few layers can be built by manual labour alone, after which a bagstacker machine is used. A 4.5 m stacker is used initially, but a 9 m machine is needed to finish off the stack. Stacks which cannot be built to full height and peaked before the start of the rains must have a sloping top throughout the construction period so that water cannot accumulate and seep through the tarpaulins.

Stacks have to be protected from rain and from excessive exposure to direct sunlight. Both jute and woven polypropylene sacks are liable to burst if the fabric is weakened by UV radiation. If a stack is wetted by rain before the tarps have been fitted, grain in jute bags can absorb and sweat off about 12 mm of water without damage. However with polypropylene bags it is suspected that water may percolate down into the stack. Tarpaulins should be re-proofed annually, and written off after four years of use. Grain in the top bags can be spoiled by stackburn and turn mouldy if top tarpaulins are not rolled aside frequently to dispel condensation which gathers on their undersides. This should be a daily depot routine except when prevented by wet weather. The task requires 8 men working under a stackmaster and takes about 1.25 hours for a 5,000 tonne stack.

Fumigation is the principal means of controlling infestation and phosphine formulations should be used at the rate of 3 to 5 tablets (equivalent to 3 to 5gms of phosphine) per tonne. Stacks must be covered with gas proof fumigation sheets which are left in place for 5 days.

Buget

Costs are in 1994 Zimbabwe dollars; the average rate of exchange was Z$ 8 = US$ 1. Ground preparation is not costed, given that the cost will vary widely depending on local conditions. Labour and stacking machines are not costed, given that GMB uses these for stacking in warehouses and outdoors, so the cost is not highly relevant to a comparison of costs for different storage structures.

Calculations are as follows:

Poles	1,500 @ Z$ 8	=	Z 12,000
Black polythene	4 rolls @ Z$ 115	=	Z 460
Tarpaulins	9 x Z$ 8,500	=	Z 76,500
Sub-total			Z 88,960
+ contingency - 10%			Z 8,896
Total in 1984 Z$			Z 97,856
Total in 1984 US$	= Z 97,856/8	=	US$ 12,232
Inflation - 3 years at 2%		=	US$ 734
Total in 1997 US$		=	US$ 12,966
Total in 1997 Namibian dollars	= US$12,966 x 4.7	=	N$ 60,940
Cost per tonne stored	= N$60,940/5,000	=	N$ 12.2/tonne

Approximately ***N$ 12 per tonne***

Additional cost using a permanent concrete plinth

Cost per sq m of plinth - quoted in Oshakati		=	N$ 275
Cost including N$ 25 per sq m contingency		=	N$ 300
Plinth size for 5,000 sq m stack	= 20 x 56 sq m	=	1,120 sq m
Cost of plinth	= 1,120 x N$ 300	=	N$336,000
Cost per tonne capacity	= N$ 336,000/5,000	=	N$ 67.2/tonne
Cost per tonne including poles, tarpaulins etc.	= N$ 12.2 + N$ 67.2	=	N$ 79.4/tonne

Approximately ***N$ 80 per tonne***