AGRICULTURAL DEVELOPMENT NGAMILAND
(ADN)

# Economic Findings and Results Dryland and Molapo Farming Systems of Western Ngamiland

By

K. Rashem

TECHNICAL REPORT

NO. 5

August, 1988

Department of Agricultural Research
Ministry of Agriculture
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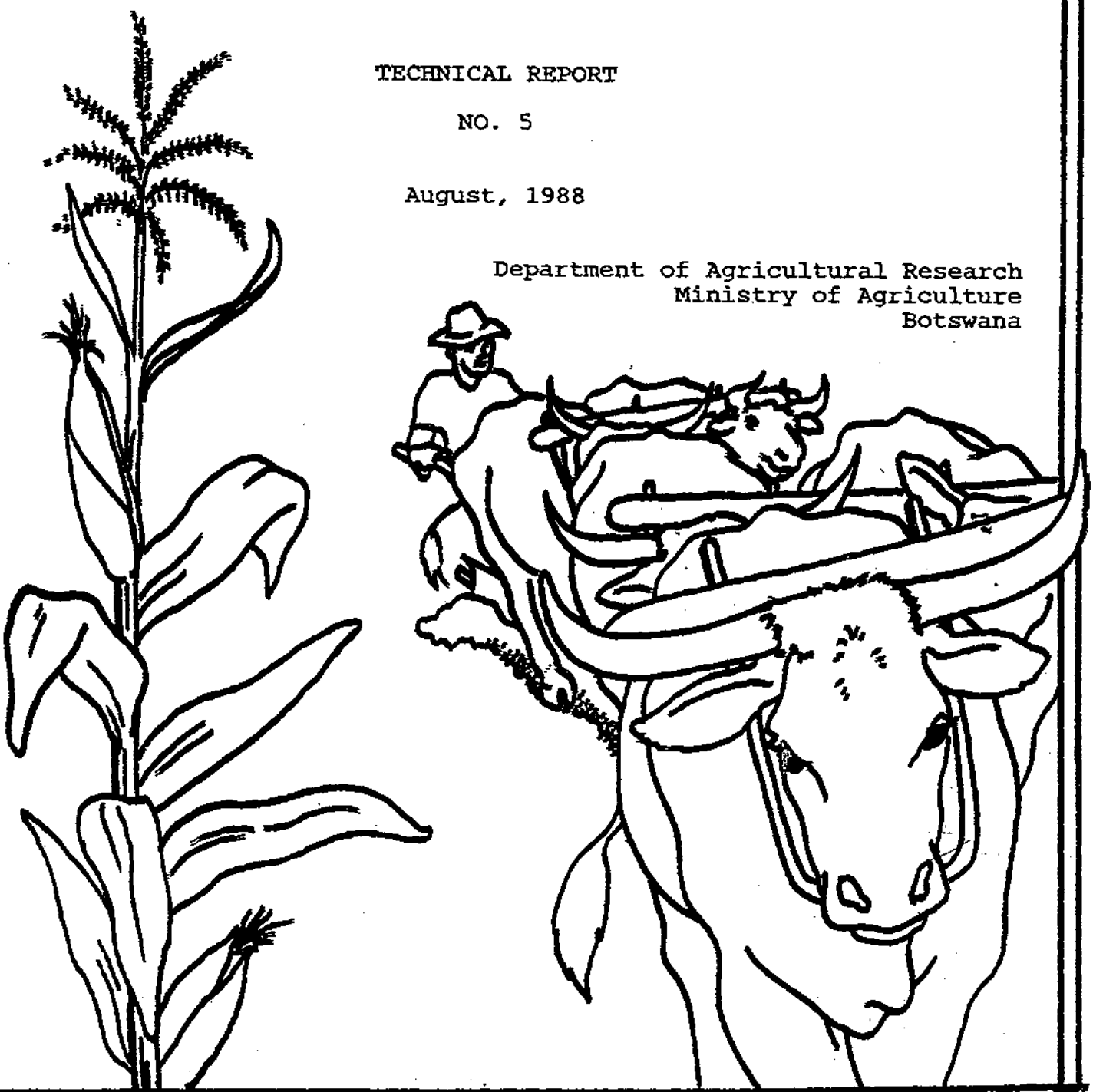

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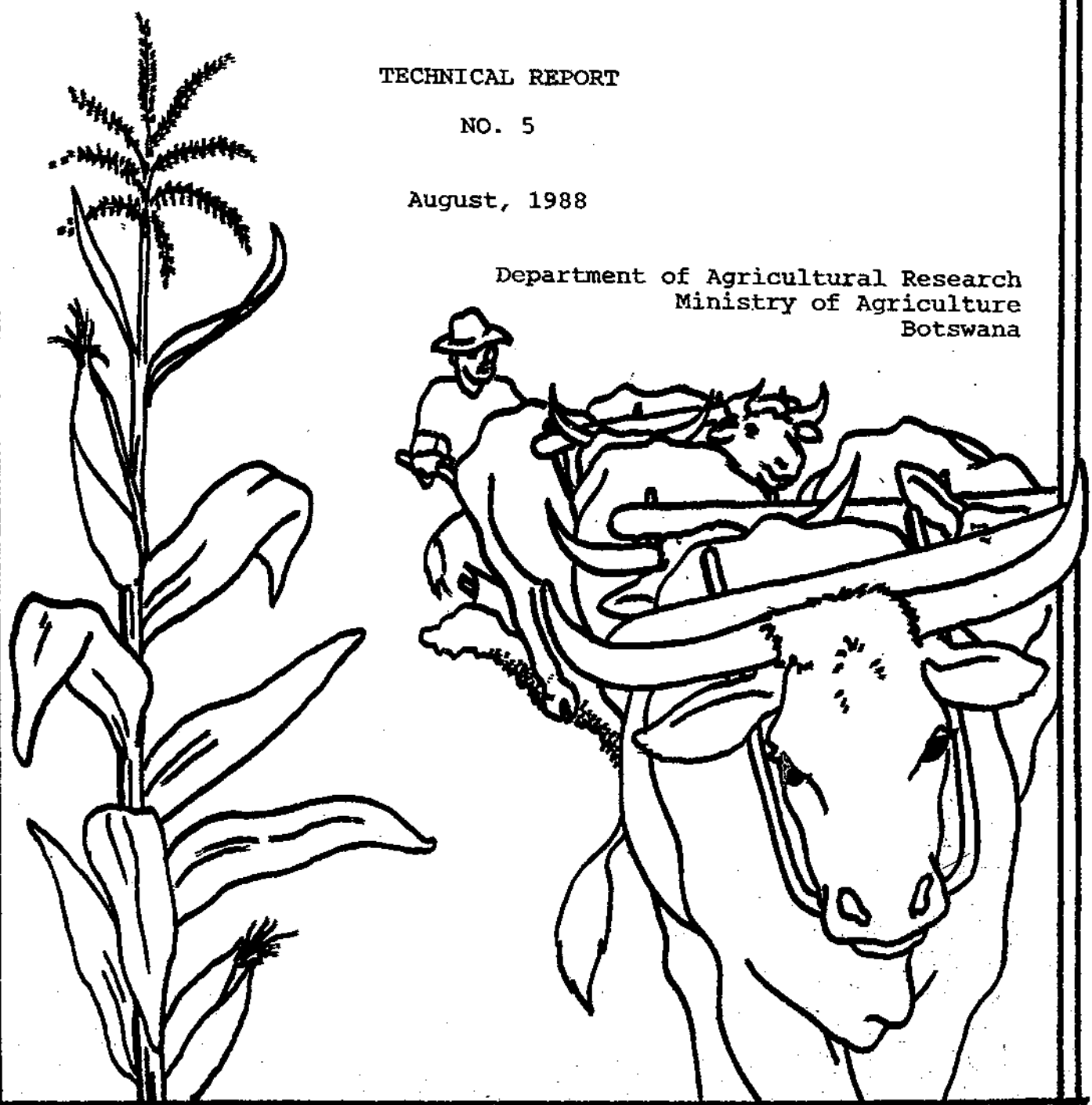

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LIST OF ABBREVIATIONS

| | |
|---|---|
| A.D. | Agricultural Demonstrator |
| A.D.N. | Agricultural Development Ngamiland |
| A.E. 10 | Agricultural Extension (small projects) |
| A.L.D.E.P. | Arable Lands Development Programme |
| A.R.A.P. | Accelerated Rainfed Arable Programme |
| C.F.D.A. | Communal First Development Area |
| D.A.O. | District Agricultural Office/Officer |
| D.A.R. | Department of Agricultural Research |
| F.A.P. | Financial Assistance Programme |
| L.A.C. | Livestock Advisory Centre |
| N.D.B. | National Development Bank |
| S.L.O.C.A. | Service to Livestock Owners in Communal Areas |
| V.D.C. | Village Development Committee |

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# 1 Introduction

The Agricultural Development Ngamiland Project (ADNP) works in the area of the Communal First Development Area (CFDA) of western Ngamiland, which is situated on the western fringe of the Okavango Delta. The project is based in the subdistrict centre Gomare. In the south the CFDA reaches as far as the village Habu, and to the village Etsha 13 in the north. The area can roughly be divided in half. The southern part with cattle rearing as the main economic activity combined with molapo farming. The northern part where dryland farming is the main economic activity.(see Bendsen & Gelmroth 1983)

## 1.1 Background

The ADN project was initiated in 1978 and got under way in 1979 with emphasis on the Farming Systems Research (FSR) approach. With the four stages:

- Descriptive stage
- Design stage
- Testing stage
- Extension stage

In line with national policy goals, as expressed in the National Development Plan 1979-85, and summarized as follows:

- Increasing food production for self sufficiency and increased cash earnings for rural households.
- Improving the general standard of living.
- Creation of productive employments.

The project have the following general objectives:

- To design, develop and promote appropriate technological packages for the different socio economic farmer groups, paying particular attention to the resource poor.
- To provide information and data about the farmers with in the designated project area to concerned agencies.

The first stage, Phase I was carried out during 1980 and consisted of a number of surveys. the study covered four villages around the Delta, Motsaudi, Makakung Danega and Xaoga. (see ADN Phase I Report 1981) Since this report only partly covers the present project area, it will not be

further elaborated upon here.

In 1981 the North West District Council designated an area on the western fringe of the Delta as a Communal First Development Area. In line with the CFDA approach, it was decided that the ADN project should operate within the CFDA. The change in project area necessitated a new descriptive survey. (see Phase I Report 1983) The recommendations put forward in this "new" Phase I Report are:

- Assist farmers without draught power to use various government programmes in order to obtain draught power.

- Introduce early maturing varieties of millet, sorghum and maize.

- Investigate optimum planting depth.

- Study troublesome weeds and find possible control measures.

- Monitoring and control of pests especially in the molapo.

- Study storage practises and attempt to reduce losses caused by rats and vevils.

- Animal husbandry management should be studied in order to assist farmers to combat diseases and parasites.

- Investigate marketing systems.

- Close linkages with other departments and local extension officers should be promoted.

With the list of problems identified during Phase I, on farm trials began with Phase II during the 1982/83 cropping season. The on farm trials were carried out in order to try and overcome some of the identified constraints . (see ADN Phase II Report 1985) The programme concentrated on three main issues:

- Testing of improved and early maturing varieties of maize, sorghum, millet, cowpeas and groundnuts.

- Investigating different planting methods to increase stand establishment.

- Seed bed preparations for better emergence and plant growth.

In the Phase I study farmers were grouped into different typologies in order to identify groups of farmers that faced similar problems. The typology was based on access to draught power, using cattle ownership as an indicator of available

draught power. Access to land was the second factor used ingrouping the farmers. During the 1982/83 season which was the beginning of Phase II, the typology of farmers was changed, to be based on actual access to draught power. From this three recommendation domains were identified. They are:

- Oxen owners; farmers who own enough animals to independently set up a complete draught team.

- Oxen borrowers/ hirers, farmers who plough with oxen but partly or entirely depends on borrowing or hiring oxen. These farmers often have problems with ploughing at the optimum time.

- Hoe farmers, farmers who carry out their arable activities entirely without draught power.

The on farm trials programme continued along the same lines during the 1983/84 season. In addition the use of herbicides was tested together with a low volume herbicide applicator. During these two seasons the trial programme was carried out with about 50 farmers and more than two hundred trials were planted.

In the 1982/83 season the project was staffed with an agricultural economist, seconded from the Department of Planning and Statistics. During the 1982/83 season a multiple visit survey was conducted. In addition to this labour data was recorded on on farm trials during the 1982/83 and 1983/84 seasons. The results from the former is presented in ADNP Phase II Report. A few of the more interesting findings from the survey are presented.

Total household cash income was P 77 for the time November 1982 to May 1983.

Farming activities contributed 70 percent of total household cash income, while off farm activities contributed 30 percent. The 70 percent resulting from farming activities equalled P 54 where P 3 was from arable farming and P 51 from cattle.

Total amount of labour input was measured. Of total labour, 87 percent of the time was spent on farming activities which should be compared with the 70 percent of total income contributed by these activities.

In February 1985 the project was again provided with an agricultural economist. this report is mainly a presentation of the economic results of work carried out by the project since the beginning of Phase III.

## 1.2 Project Farmers and Representativity

The data collection and information gathering have been concentrated on farmers with which the project has cooperated. This especially concerns agronomic information and data. Results and data regarding traditional arable farming and regarding new technologies that have been tested, are all obtained from the project farmers fields. With this background it is important to know how these farmers were selected and how representative they are for the farmers in the area.

Farmers were selected at Kgotla meetings in October 1982.(see ADN Phase II Report) At these meetings volunteer farmers were asked for. Even though attempts were made in order to have farmers that represented different levels of wealth, it is inevitable that farmers who volunteer are more progressive than others. Since the first season of 1982/83 a gradual selection of farmers has taken place. Farmers who were uncooperative or had fields that for one reason or another were not likely to produce anything, were for obvious reasons excluded. Altogether this situation is likely to have resulted in project farmers that are a bit over average when it comes to resource control and attitudes towards innovations. In Table 1 project farmers are compared to farmers in the area.

Table 1. Project Farmers Compared to Farmers in the Area in Percent of.

| | All Farmers | Project Farmers |
|---|---|---|
| Male headed households | 54 | 91 |
| Cattle owners | 67 | 90 |
| Plants every year | 92 | 100 |
| Ploughing with oxen | 92 | 97 |
| Owns a plough | 59 | 75 |
| Owns a harrow | 1 | 13 |
| Someone with employment | 42 | 58 |
| Sold cattle | 53 | 58 |
| Sold grain | 21 | 45 |
| Knowledge about ALDEP | 17 | 45 |

From Table 1 it is clear that the project farmers are a bit above average farmers when it comes to arable practises and resource control for arable farming. What is perhaps not as obvious is that the project farmers are generally more dependent on arable farming and therefore more interested in improvements. When arable development is coming in the area it is this group of farmers who is initially going to implement the development.

## 2 Farming Systems in the Area

The project area includes three distinctly different Farming Systems. They are:

- Dryland farming practised mainly by the Hambukushu.
- Molapo farming practised mainly by the Bayei.
- Pastoral system practised mainly by the Maherero.

The Pastoral system has received very little attention by the project and is therefore not further mentioned.

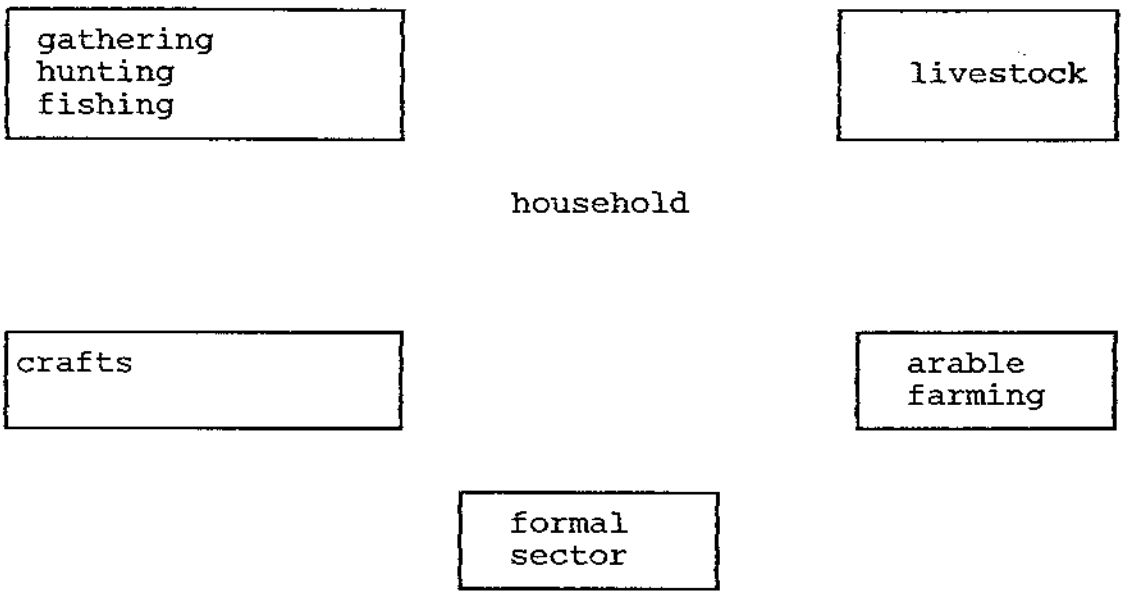
Within the area there are about 2 700 households (1981 census extrapolated to 1987) and 13 000 inhabitants. As much as 90 percent of the households are involved in arable farming.

### 2.1 Farming and Subsistence

The strength of the traditional farming systems in the area is their flexibility and the spread of risks that the systems allow. Traditionally there was always something to fall back on in years when crops failed or when livestock died, either from drought or diseases. Today this system begins to fall apart, the main reason being the population growth. The system just can not support the present population. The result is that during drought years, people are more and more dependent on food aid, and the migration to urban areas is increasing.

The traditional farming system can schematically be divided into five main activities (fig 1) each one contributing to the rural households subsistance.

Figure 1. The Rural Household and its Subsistence Sources




It is of interest to study each one of the five "boxes", how their importance change with development, time and population growth.

### 2.1.1. Livestock

The livestock sector is without doubt by far the most important contributor to the rural households subsistance and the most important cash income source. It is however not likely that the livestock sector can sustain its relative importance. The decline in relative importance of the livestock sector is partly due to the rapid increase of the population. The major factor is however the livestock production system. The livestock production is not based on sustainability; it is depleting and destroying the resource it is based upon -the pasture land.

### 2.1.2. Gathering, Hunting and Fishing

In former times it is likely that this sector was the main contributor to the subsistence of the rural population. In drought years as much as 70 percent of the food was obtained from this sector (see T.Tlou 1984). The relative importance of gathering (used as a common expression for the sector) is however rapidly declining but it is still an important contributor, especially during drought years. There are many factors contributing to the decrease in importance of this sector. Population growth obviously ,the destruction of resources the sector is based on, destruction caused by an

increasing pressure on the land both from people and from domestic animals. Lastly the break down of the traditional system to protect these resources.

### 2.1.3. Crafts

Under this heading comes crafts like baskets and other artifacts, also craftman's work like carpentry, traditional house building, the production of traditional tools and utensils etc.

The importance of baskets and other artifacts has increased due to efforts made by different organisations. However the importance of traditional craftmanship is declining. Tools and utensils traditionally made, can now be substituted with fabricated items, which are often more suited for their purposes.

### 2.1.4. Arable Farming

Arable farming has not been and to some extent is still not as important as is often implicated by different authorities. By experience and tradition, rural households know that as the situation is they can not rely more on arable farming. The traditional arable farming system is developed and relied upon as much as natural constraints admit. It is an extensive system with minimal input that in good years will give a fair return and in bad years no return. The extensivity of the system ensures that the losses in bad years are kept at a minimum. It is obviously that an activity that regularly will hardly return anything for a number of consecutive years can not be relied upon to any greater extent.

### 2.1.5. The Formal Sector

The formal sector is the sector that has increased most in significance. It is also the sector towards which rural households put their hopes and aspirations. It has an enormous magnetism since entering the sector means security plus an income and living standard that vastly exceeds what can be expected from the rural farming system. It is however obvious that most of the people aspiring to enter the formal sector will be disappointed. They are left with the choice between unemployment in urban centres or return to the hardships of the rural dwelling life. More and more people are making the choice in favour of the first alternative.

### 2.1.6 Summary

The importance of cattle for the rural household is big. It is of interest to try and estimate how important cattle and smallstock is compared to arable agriculture.

In 1982/83 the multiple visit survey, found the cash investments and revenues for the surveyed households as presented in Table 2.

Table 2. Average Cash Investments and Revenues for Arable and Cattle Farming, in Pula per Year.

| | Investments | Revenues |
|---|---|---|
| Arable farming | 4.00 | 3.00 |
| Cattle | 7.00 | 51.00 |

(Source: ADN Phase II Report)

These figures were collected only during one year which was a drought year. But it is interesting to see the enormous difference in return to invested cash. Cash is in the basically subsistence farming systems in the area, in short supply, and it can thus be expected that households try to find means of obtaining cash.

The Quantification survey in 1985 did not include investments but estimated total sales within the area. In Table 3 the total sale values from different activities are presented. The sales include cash sales as well as barter.

Table 3. Sales Derived from Different Activities 1984/85 Pula per Household.

| | Dryland area | Molapo area | Total |
|---|---|---|---|
| Cattle | 33 | 346 | 168 |
| Milk | 23 | 19 | 21 |
| Small stock | 8 | 12 | 10 |
| Grain | 5 | 4 | 5 |
| Handicrafts | N/A | N/A | 55 |
| Total | | | 259 |

(Compiled from: ADN Technical Report No.1, Kgotla archives, Botswana craft and other basket buyers.)

Table 3 does only compare different activities and their production of goods that is sold, this does of course not give an altogether fair comparison. Crops are for example grown mainly for own consumption, and cattle owners do consume considerable quantities of milk. For a dryland farmer who plants on average 2.5 hectares (DA Office records) this means an expected production, expressed in Pula of P 160. Milk for household consumption is estimated to three litres per household and day, which corresponds to IFPP findings, (see IFPP main report Phase II) where household milk consumption is estimated to 10 percent of calorific intake. With a price of P 0.25 per litre this gives a value of P 270 per year.

What might be surprising is that handicrafts is second to livestock regarding cash incomes. Two surveys carried out in Etsha (E.Terry 1984) and Gomare (E.Terry 1986) found, that in Etsha a basket maker on average sells for P 90 annually. In Gomare the figure was P 45. Sales do fluctuate considerably between years, but that basket making is of great importance is clear.

## 2.2 Dryland Farming System

The Dryland farming system is the most pronounced arable system within the project area. It is also a subsistence farming system, even though some grain is sold in order to obtain cash. The Hambukushu that came to Botswana as refugees from Angola during the late sixties, were not able to bring any cattle with them. During their first years of cultivation they relied entirely on human labour (pers. comm. M. Thomas). Even though they are rapidly obtaining more and more livestock the importance of livestock is still relatively

low. Cattle appears to be held mainly as draught power and herds are generally small. Animals used as draught power are very well trained. In addition to livestock and crops, production of handicrafts, fishing and gathering of wild fruits and plants are common activities.

In the Etsha area where Dryland farming is prevalent, there are about 1 350 households and 5 800 inhabitants. They cultivate some 3 600 hectares (Bendsen and Gelmroth 1983). Of the households more than nine out of ten are involved in arable farming, which gives that there are about 1 250 arable farmers in the area. The average farmer during the 1986/87 season ploughed 2,4 hectares, which implicates that all the land is not planted every year, which is supported by field observations. Land is fallowed in order to reestablish fertility.

The main crop grown is millet which also is the staple food. Sorghum is planted and used mainly for beer brewing. Maize is tried when rains look promising but rarely gives any returns. Besides these crops groundnuts, juggo beans, cowpeas, mellons and pumpkins are grown. The arable practises and favoured crops are well adapted to low rainfall. The report will mainly concentrate on millet cropping, since about 80 percent of the area planted each year is planted with millet. Farmers do however state that they used to plant more sorghum and even maize, but during the long drought they have more and more turned towards millet.

Farmers practising dryland farming has been grouped into three different recommendation domains, according to their access and use of animal draught power. In Table 4 the recommendation domains are presented together with estimates of how many farmers who come under each domain.

Table 4. Percent and Approximate Number of Dryland Farmers in Each Recommendation Domain.

| Recommendation domain | Percent of Farmers | | | Number of Farmers | | |
|---|---|---|---|---|---|---|
| | Total | Male | Female | Total | Male | Female |
| Oxen owners | 41 | 57 | 19 | 500 | 390 | 110 |
| Oxen borrowers | 44 | 37 | 53 | 550 | 250 | 300 |
| Hoe farmers | 15 | 6 | 28 | 200 | 50 | 150 |
| Total | 100 | 100 | 100 | 1 250 | 690 | 560 |

It is obvious that the control of draught power is skewed in favour of male headed households. Noticeable is however the number of households that do have draught power. Considering that fifteen years ago no one, according to the former resettlement officer, brought cattle.

The different recommendation domains favour partly different arable practises and thus require different resources and to some extent different amount of the same resource. Furthermore different technological innovations are available for each domain. In Table 5 estimates of the resource requirements for different arable activities as traditionally practised are presented. Average yields per hectare planted land is for millet during four seasons 250 kg/ha, which is equal to P 65.

Table 5. Resource Requirements for Arable Activities in Traditional Dryland Farming, Hours per Hectare.

| | Farmers using oxen | | Hoe farmers |
|---|---|---|---|
| Activity | Man hours | Oxen hours | Man hours |
| Ploughing[1] | 18 | 24 | - |
| Clearing | - | - | 100 |
| Planting 3rd furrow | 12 | - | - |
| Planting with hoe | - | - | 27 |
| Weeding | 70 | - | 70 |
| Birdscaring | 35 | - | 35 |
| Harvesting | 40 | - | 40 |
| Total Hours | 175 | 24 | 272 |
| Return to labour | P 0.37/hour | | P 0.24/hour |

[1] Ploughing one hectare takes 12 hours with two oxen and one or two persons

The only additional investments are seeds and for oxen owners, apart from the animals, a plough with yokes and chains. Most of the seeds that are used are obtained free from the Government, and implements like ploughs are subsidised with 85 percent. No special dwellings have to be maintained since lands are close to permanent dwellings, the same goes for oxen owners. Cattle are kept in kraals within walking distance from permanent dwellings as well as from the

lands.

The level of investment is low as is the expected return. The return to labour is a bit misleading. It is an expression for average return. A farmer does however have to face the possibility that there will be no return at all. For a dryland farmer this possibility or more accurately, risk of obtaining no yield at all, is as high as 60 percent.

## 2.3 Molapo Farming

The molapo farming system is more dependent on livestock than the dryland system. Cattle is the major income source and arable agriculture is based on animal draught power. The dependence on arable crops is relatively low. In addition to livestock and arable agriculture, handicrafts, fishing, hunting and gathering of wild fruits and plants are common activities.

In the area where molapo farming is prevalent there are about 1 400 households and 7 500 inhabitants. They cultivate some 3 500 hectares (see Bendsen and Gelmroth 1983). Of all the households about 1 300 are active arable farmers. The cultivated area does not reflect area cultivated a single year. Farmers move around according to which fields that have been flooded. One farmer often have access to several fields in different locations, and plant those fields that have the required moisture conditions at time of planting.

The area where molapo farming takes place is known as the Nokaneng flats. The soils are very fertile, and cover an area of roughly 50 000 hectares (see SMEC 1987). At present, areas that are cultivated are old river beds or other depressions that are flooded or moistened by a rising ground water. The availability of molapo fields that are flooded is getting more and more scarce. The western side of the Okavango Delta is rapidly drying up and less and less fields are flooded. This has resulted in so called dry molapo fields. These fields rely on rainfall to obtain moisture for planting. The immediate cause for the drying up of the area is the reduced flow in the Thaoge river. In former times the Thaoge was a perennial river that flowed all the way down to lake Ngami (see C.J. Andersson 1856). Today the flow rarely reach as far south as Gomare, even during the flood season. The Thaoge river has dried up about 150 km in 125 years, giving an average of more than one kilometre annually. That such a rapid change of environment have put enormous stress on the traditional farming system is obvious.

The most favoured crop is maize which is planted on about 80-90 percent of the lands. Other crops are sorghum, groundnuts, beans, mellons and pumpkins. The arable practises as well as favoured crops are adapted to wet molapo conditions, even though sorghum is becoming more common on dry molapo fields.

The fact that molapo farmers practise molapo methods on rainfed fields does of course often result in crop failure. The major part of the project farmers do however have access to wet molapo fields.

In the molapo with its clay soil and heavy weed infestation (see ADN Technical Report No.3) all fields are ploughed, using oxen, or in a few cases donkeys. For this reason molapo farmers have been divided into two recommendation domains, oxen owners and oxen borrowers or hirers. In Table 6 the recommendation domains are represented according to their size.

Table 6. Percent and Approximate Number of Farmers in Each Recommendation Domain.

| Recommendation domain | Percent of Farmers | | | Number of Farmers | | |
|---|---|---|---|---|---|---|
| | Total | Male | Female | Total | Male | Female |
| Oxen owners | 72 | 78 | 45 | 940 | 730 | 210 |
| Oxen borrowers | 28 | 22 | 55 | 360 | 50 | 310 |
| Total | 100 | 100 | 100 | 1 300 | 780 | 520 |

(Compiled from: ADN Technical Report No.1 and 1981 Census Extrapolated)

In the area a draught team normally consists of eight to ten animals. Often as many as twelve animals are used, and never less than six. Considering this, the number of farmers who come into the category of oxen owners is higher than expected.

Molapo farming is resource demanding. Often fields can not be cultivated for many years in a row, due to changes in the annual floods of the Delta. This results in that ploughing often has to be carried in fields that have been fallowed for some years, which makes ploughing slow and weed control hard. Furthermore fences, if erected can not be used every season. In Table 7 resource demand for molapo farmers is presented.

Table 7. Resource Requirements for Arable Activities in Traditional Molapo Farming, Hours per Hectare.

| Activity | Man hours | Oxen hours |
|---|---|---|
| Ploughing | 50 | 200 |
| Broadcasting | 2 | - |
| Weeding | 100 | - |
| Guarding | 35 | - |
| Harvesting | 80 | - |
| Total hours | 267 | 200 |
| Return to labour | P 0.60/hour | |

The investments necessary in addition to labour and draught animals, are seeds and a plough with yokes and chains. Ten kilogram of seed per hectare is distributed freely by the Government, but farmers are using as much as 20-30 kg of seed per hectare to compensate for the poor germination obtained when broadcasting. The high seed rates make it necessary for farmers to save or buy seed in addition to issued seed. Furthermore most farmers have to maintain a special lands area dwelling during the cropping season. The investments are quite much higher than for dryland farmers but this is compensated by higher expected returns. Also molapo farmers have to consider the risk of no return at all, which of course is serious, since quite a lot of effort has been put into the crop. For a molapo farmer this risk is as high as 75 percent, meaning three hectares of four, will not return anything. A farmer can expect to obtain about two tonnes per harvested hectare, which compares with 500 kg per planted hectare.

## 2.4 Livestock

Livestock and then referring mainly to cattle, is in this area as in the rest of Botswana, the most important asset. Apart from being the most important cash income source, cattle provides meat, milk, draught power and social recognition. It is a very extensive system with a minimum of inputs and a relatively low output. The result is a low level of management and a low offtake rate. In Table 8 livestock ownership is presented, divided in dryland and molapo areas.

Table 8. Ownership of Livestock, Dryland and Molapo Farmers. Percent of all Households.

| | Dryland Area | | | Molapo Area | | |
|---|---|---|---|---|---|---|
| | Male | Female | Total | Male | Female | Total |
| Owns Cattle | 73 | 44 | 60 | 87 | 47 | 69 |
| Mafisa Cattle | 31 | 9 | 21 | 49 | 18 | 35 |
| Owns or Mafisa | 74 | 49 | 62 | 92 | 47 | 72 |
| Owns Goats | 59 | 34 | 48 | 88 | 58 | 75 |
| Owns Chickens | 64 | 49 | 57 | 61 | 55 | 58 |

(Compiled from: ADN Technical Report No.I)

Roughly twenty percent of all the households do not own any livestock at all. The practise of Mafisa cattle is a way for a cattle owner to get cattle managed as well as to spread his herd over several areas and thus reducing risk. The receiver benefits by having the right of using the animals as draught power and by keeping the milk, for consumption or sale. The mafisa holder is usually also paid one calf every year. The mafisa system is an economic arrangement, and not a system where households without cattle obtains cattle. There are of course examples where households who owns no cattle, do have mafisa cattle. This is however unusual. Of all households that have mafisa cattle about 30 percent, only between one and two percent are households without own cattle. A cattle owner, before he leaves his animals to someone as mafisa cattle, makes sure that the receiver has necessary labour and experience for managing the animals. This does tend to exclude poorer and female headed households.

The level of management regarding livestock is low. This might be an expression of lack of knowledge about different management methods. Every management method wether it is dehorning or feeding with mineral supplies do require additional investments. The adoption of a new management method is an intensification of the present system. The low level of management can be an expression that the present cattle breeding system does not afford any intensifications.

The management methods that are widely adopted are dehorning and castration. More or less all cattle owners practise these methods even though they do not do it on all their animals. Castration of bulls is often done when the animals are mature. This is done in order to see if the bull should be used for breeding, if not it is castrated. To castrate mature animals means that most of the benefit with castrating is lost. Apart from these methods, all cattle with a few

exceptions are vaccinated against foot and mouth disease, this is compulsory and carried out free of charge by the Department of Veterinary Services. They also free of charge vaccinate cattle against Anthrax, Contagious abortion and Blackquarter evil. About 80 percent of the cattle owners claim to use this service. Other management methods are little used as presented in Table 9.

Table 9. Practise of Management Methods and Use of Drugs and Vaccines, Percent of Cattle Owners.

| | Dryland area | Molapo Area | Total |
|---|---|---|---|
| Improved Bulls[1] | 3 | 13 | 8 |
| Salt | 1 | 0 | 1 |
| Bonemeal | 1 | 0 | 1 |
| Pasturella | 12 | 72 | 44 |
| Parafilaria | 5 | 30 | 19 |
| Calf Parathyphoid | 5 | 18 | 12 |
| Internal Parasites | 8 | 49 | 30 |
| External parasites | 6 | 39 | 24 |

[1] Use of Government subsidy for purchase of breeding bull.

(Compiled from: ADN Technical Report No.1)

When studying Table 9 the impression is not that the level of management is very low, this is contradicting to the statement that cattle management is poor. The explanation to this might be that farmers once have vaccinated an animal or that they vaccinate only the most valuable animals. In Table 10 the sales figures for the Gomare Livestock Advisory Centre (LAC) are presented for some vaccines and drugs. The Gomare LAC serves the whole Ngamiland West district. According to Agricultural Statistics, the district for the period 1981-1985 had on average 140 000 heads.

Table 10. Sales of Vaccines and Drugs at Gomare LAC. For Vaccines Presented in Doses and for Drugs as Number of Full Treatments.

| Year | Pasturella | Calf Parathyphoid | Trodax[1] |
|---|---|---|---|
| | doses | doses | treatments |
| 1983 | 2 360 | 114 | 780 |
| 1984 | 2 580 | 0 | 120 |
| 1985 | 1 900 | 100 | 570 |
| 1986 | 2 000 | 0 | 585 |
| 1987 | 2 360 | 0 | 675 |
| Total | 11 200 | 214 | 2 730 |

[1] Trodax is used as drug against Parafilaria and Internal Parasites

(Compiled from: Gomare LAC's store books)

When looking on Table 10 the picture of cattle management is different from that given by Table 9. Less than two percent of the cattle within Ngamiland West is vaccinated against Pasturella, which according to Veterinary staff is the most serious disease within the area. The situation looks even more negative when two cattle owners stands for almost half of the purchases of vaccines. Less than seven thousand Pula is spent on the three most severe diseases in the area, during five years. This corresponds to less than one Thebe per animal and year. Regarding smallstock the use of improved management methods are non existent. To explain why cattle owners do not use vaccines and drugs is hard. The vaccines are sold in Gomare and they are not expensive. To vaccinate one animal against Pasturella costs 14 Thebe. If a farmer can save the life of one animal by vaccinating it, that alone pays for the vaccination of over one thousand animals.

## 2.5 Off Farm Activities

Off farm activities are important for the rural households subsistence, the question is how important these activities are, compared to farming. In Table 3 it was shown that the average household generated P 55 from basket sales. Basket making is also the activity that most households mention as their most important, income generating, off farm activity. In Table 11 the four most mentioned income generating activities, besides farming are presented.

Table 11. The Four Most Mentioned Activities that are Income Generating. Percent of All Households.

| | Male Households | Female Households | Total |
|---|---|---|---|
| Basket making | 61 | 63 | 62 |
| Beer brewing | 44 | 44 | 44 |
| Collecting building material | 25 | 15 | 20 |
| Selling bread and porridge | 6 | 14 | 10 |
| One of above | 80 | 80 | 80 |

(Compiled from: ADN Technical Report No.1)

These activities apart from being major income sources, also provide goods for own consumption or use. E. Terry 1986, concludes that amongst basketmakers, basketmaking is the most important income source, including farming. In addition to these activities comes, fishing, hunting and gathering of edible plants and fruits. All important contributors for the rural households subsistence.

Formal or casual employment is another important, if not the most important income source. In Table 12 the percentages and number of households where at least one member have some form of employment are presented.

Table 12. Percent and Number of Households with at Least One Member Having Employment.

| | Percent | No of Households |
|---|---|---|
| Formal employment | 28 | 725 |
| Casual employment | 21 | 545 |
| Formal or Casual | 43 | 1 115 |

(Compiled from: ADN Technical Report No.1)

To estimate the amount of money this brings in to the area is of course very inaccurate and will have to depend on rather week assumptions. Most of the persons with formal employment, work outside the area and send money home. While those with casual employment mostly works in Government relief programmes. In attempting to estimate the importance of employments, the following assumptions are made:

- Formal employment is paid Government minimum salary of Pula 6.68 per day 1986. which gives Pula 140 per month.
- Since most persons with formal employment works outside the area, the assumption is that they send ten percent of their income to their family.
- Casual employment is paid with drought relief payment of Pula 3.75 per day and have employment for three month during one year.

The assumptions are made so at least not to over estimate the importance of employment. With these assumptions formal employment brings in 122 000 Pula each year. Casual employment brings in 123 000 Pula each year, giving a total of 245 000 Pula. For comparison this is divided on total number of households, giving Pula 89 per household and year.

## 3 Constraints to Arable Development

In this respect constraints means factors that in one way or another hinder the adoption of improved arable practises, or reduces the incentives for increased arable investments and production. An attempt is made to categorise such factors. Constraints are grouped into three categories, they are:

- Economic factors
- Human factors
- Cultural and Social factors

The definition of each category is as will be seen very wide and it can in some cases be discussed if a factor is cultural or economic. Often economic considerations are the background to cultural traditions.

### 3.1 Economic Constraints

Under this heading comes the pay off from arable farming. How arable farming stands up in the competition for the farming households resources. Vital in the resource allocation is the farmers need to and aspiration to minimise and spread risk. The conclusions are based on that farmers behave in a rational way. When given a choice a farmer will select the alternative that from an economic point of view will give him the highest return.

#### 3.1.1 Risk

Arable farming will always involve some degree of risk or uncertainty. The reason for this is that arable farming is depending on a number of factors that are impossible or very hard to control for a farmer. In order to handle risk, farmers diversify their resources between and within different enterprises. In a subsistence farming system were the present system is more or less the same as it was decades ago the resource allocation to a great extent is based on traditions. In this respect traditions are experiences obtained by earlier generations. Over time traditions are altered in order to reflect more recent experiences. To change a tradition that is based on generations of experiences require obvious and reliable information that a change will be of benefit.

When allocating resources between different options a couple of basic rules are applied. The General rule is popularly expressed as "don't put all the eggs in one basket". this rule applies to subsistence farming as well as to advanced

portfolio theory regarding shares and stocks. The attraction of the rule is that the sum of the total net benefits is greater than the sum of the benefits from each single enterprise.

In the operation of deciding how much resources are going into one enterprise the farmer aims at finding as good relationship between expected benefit and exposure to risk, as possible. The risk exposure is a function of risk and the amount of resources exposed to that risk. If the expected benefit is high one is prepared to accept a higher risk or allocate more resources. thus one is prepared to accept quite low benefits if there is very little risk involved.

The balance between risk and benefit and its implications on resource allocation is quite obvious when comparing different enterprises. It does however also apply on the allocation of resources between different activities within one single enterprise. The ploughing activity does for example involve more risk than the harvesting activity.

There are however situations when these rules can not be relied upon. If there is only one option or the consequences of failure are to serious to be manageable. In such situations a farmer might have to concentrate all his resources in one enterprise, even though the risk/benefit relationship is unfavourable. One effect of this is that resource poor households tend to select low profit low risk enterprises. Two factors are involved in that selection. Firstly high risk high profit enterprises are often more resource demanding which often exclude them as options for poorer households, simply because they do not have the required resources. Secondly, even though a poor household do have enough resources they can not face the higher risk because a failure would mean to serious consequences.

The ADN project is now going on its fifth year of on farm trials. Results from the first two seasons, or rather the lack of results is quite scaring. From over 200 planted trials on farmers fields less then 60 produced any yield. This is probably a quite accurate reflection of the average farmers situation. The agronomists from the project were only involved when the activity that the trial consisted of was carried out. During the rest of the season the management of the plot was entirely decided on and carried out by the farmer.

Recording of data and collection of information from on farm trials has so far been concentrated on the results. Little information was collected on the non results. This makes it difficult to accurately estimate how big the risks are and exactly what risks there are. Afterwards it is hard to find out the real reason for a failure. Often there is more than one reason, which one that actually made the farmer to abandon the field is not always clear.

Molapo farming is a high risk,high profit enterprise, that is carried out on relatively fertile soils. Average yield per hectare harvested land for three seasons is 2100 kg/ha with very high potential yields, over six tons of maize per hectare has been recorded. The setback is that molapo farming is a very risky enterprise that to a big extent reduce the total benefit from molapo farming, despite the high yields. Recalculated the yield on area planted was 520kg/ha. Furthermore molapo farming is very resource demanding. Ploughing is never done with less than six animals and often as many as ten to twelve animals are required. Fields are often heavily infested with weeds which take a considerable effort to manage. The total risk from ploughing to harvesting is roughly 75 percent.

The fact that recording of data has been concentrated on successful trials, makes the estimates of how big the risks are and what risks there are as presented in figure 2, quite rough and only includes the biggest risks encountered by a molapo farmer.

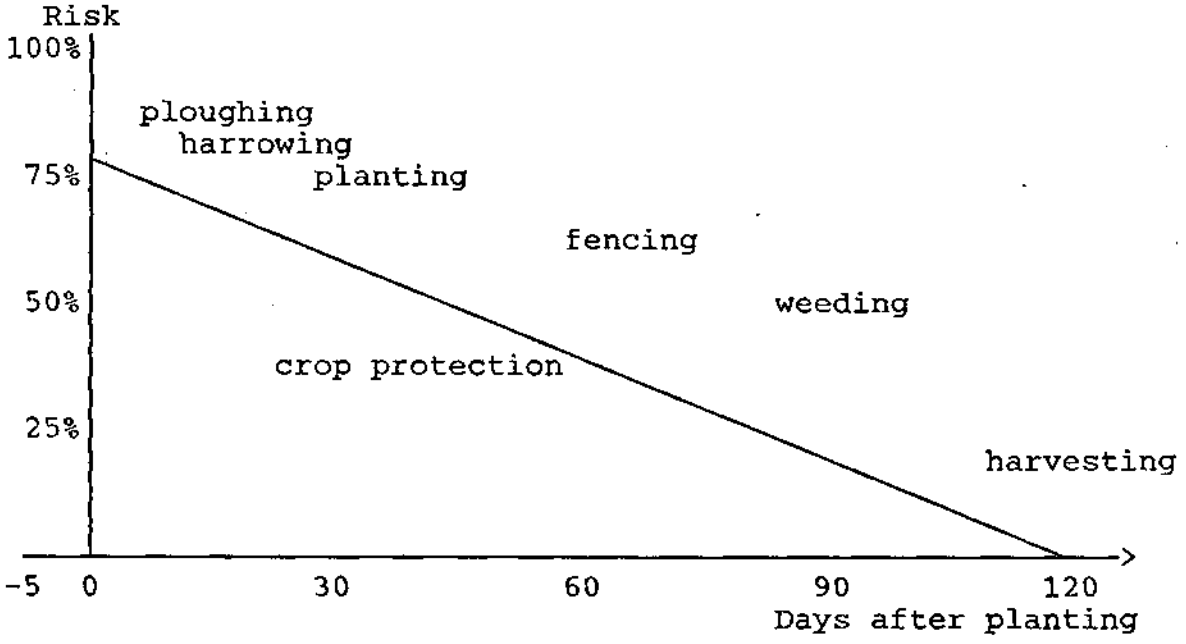
Figure 2. Risks in Molapo Farming

| Successful | Livestock | Pests | Poor germin. | Dro-ught | Flood |
|---|---|---|---|---|---|
| 25% | 20% | 17% | 15% | 12% | 11% |

- 20% failed due to livestock damage. In some cases the damage was done by wild animals.
- 17% failed due to pests, common are cutworm, stalkborer, mice, birds and springhares.
- 15% failed due to poor germination. This is often caused by unfavourable moisture conditions when planting. The field is either to wet or to dry.
- 12% failed due to drought. Higher situated fields are sensitive to draught even though the crop is established on the moisture from the receding flood. Farmers are forced to use these fields in years of high flood.
- 11% failed due to flooding. During years with a low flood farmers are forced to use fields that are situated in low places. These fields are exposed to flooding in case of a period with heavy rainfall.

It should also be realized that different activities carried out by farmers on the field are exposed to different degrees of risk. This variation of risk is a function of time as presented in figure 3.

Figure 3. Activities and Variation in Risk in Molapo Farming.




- Ploughing is one of the major operations carried out on a molapo field. It requires two men and eight to ten oxen for five to six days to plough one hectare. Thus the operation involves a high exposure to risk. Any operation carried out at this stage has an expectancy of being successful of 25%.

- Planting is like ploughing an operation with high risk of being unsuccessful.

- Fencing. Since the flood varies every year it is rarely a farmer can use the same field for more than a couple of years in row. This means that a bush fence can only be used for one or two seasons. Fencing is a resource demanding operation especially when suitable fencing material is hard to find close by the fields. Farmers usually wait to fence a field until the crop has established well, in order to avoid as much risk as possible involved with the operation.

- Weeding is often carried out quite some time after planting and in some cases not at all. If the crop does not seem to promise a good yield a farmer often abandon the field rather then investing more resources without even a likelihood of a good return. Late weeding involves less risk than weeding early during the season.

- Crop protection. In order to guard the field against animals and birds a person often stays at the field in a temporary shelter, during parts of the season. The guarding intensifies with increased likelihood of a successful crop.

- Harvesting will always get the required resources. The exposure to risk is none and thus one can be certain that the operation will not be in vain.

Dryland farming is a less profitable and less risky enterprise than molapo farming. It does involve a considerably reduced degree of risk exposure since firstly the overall risk is less and secondly since it requires less resources. Average yield per area harvested is 600kg/ha and 360kg/ha planted land. The recording of causes for failures has also for dryland farming been infrequent, thus the figures presented in Figure 4 are rough estimates.

Figure 4. Risks in Dryland Farming.

| Successful | Poor Germination | Pests | Dro-ught | Live-stock |
|---|---|---|---|---|
| 40% | 22% | 18% | 10% | 10% |

- 22% failed due to poor germination. This shows how hard it is to establish a crop in a dryland field. Often the fields are planted without enough moisture to ensure good germination. Another suspicion is that seeds are destroyed by high soil temperatures

- 18% failed due to pests. Trips, termites and mice are frequent. Birds is also a big problem especially since they do their harm just before harvesting.

- 10% failed due to drought. This is surprisingly low since the trials were carried out during the present draught. Dryland farmers in Etsha are very skilled in soil moisture conservation which enables them to produce a yield on very little rainfall. The drought does of course reduce yields but it rarely causes a complete failure.

- 10% failed due to livestock damage. This is only half of the damage caused by livestock in the molapo area. The dryland fields are more stationary than molapo fields and this is an incentive for permanent fencing.

The overall risk with dryland farming is 60 percent, or differently put, the chances of success is 40 percent, which is almost double the chances in molapo farming.

During the long drought the expectations on the size of the yield from a successful dryland field has gradually been reduced. The traditionally dryland farmers in Etsha have during the last three years started with molapo farming. It started with a few farmers the first year and the number has increased for each following year. The farmers have reallocated their resources in order to handle the change in relationship between risk and benefit.

In many cases it is impossible for an individual to control risk, sometimes this can be solved on larger scale. Within the CFDA there are two examples of where risks are tried to be overcome on a larger scale than possible for the individual farmer. In Etsha a 30 km long driftfence has been erected as a joint effort involving thirteen villages to control livestock and keep them away from the fields during the cropping season. In the molapo area a major problem is that farmers can not use their fields every year. This is caused by the variation in flood level between years. This variation increase the risk for flooding and drought. Furthermore it is an obstacle effecting fencing. It is hoped that the variation in flood level will be decreased by bypassing the blocked Thaoge river. The by-pass channel is at present under construction and is planned to be completed in 1988.

The perhaps most important aspect of risk when considering farmers willingness to allocate more resources to arable farming, is the distribution of risk between years. With the climatic conditions in Botswana, that causes a number of successive years of drought. The farmers have to face the risk of three or even up to five years with hardly any return at all from arable farming. For the farmers this mean that even if they adopt improved arable practises that during good years enables them to increase production, they are going to starve when the drought comes. They can not store or accumulate enough during good years in order to overlap such long periods of crop failures.

### 3.1.2 Economic Relationships

Arable farming has to compete with all other activities that the rural household is involved in, in order to make a livelihood. When deciding which activities to allocate resources to, the farmer has to estimate the benefit from each activity. These estimates are for farming activities based on experiences, while employment for example has a fixed certain benefit.

What is often put forward as a constraint to arable farming, is lack of labour. (see Ngamiland Village Survey 1979, Agricultural Practices and Attitudes Survey 1980,etc) Often farmers expressed shortage of labour is mistaken for actual shortage of people to carry out necessary tasks. This might be true in a few cases, but more often the explanation is that they do not allocate more labour to arable farming, because there are other activities that are of greater benefit. This is clearly proved by the contradiction, that at the same time as farmers claim to have shortage of labour for arable farming, rural roads have no problem to find hundreds of people, prepared to work for Pula 0.66 an hour. This example shows to things, firstly the labour is there. That farmers do behave rational. Who in his right mind would work with arable farming for an uncertain return of 60 Thebe an hour, when he can work for a certain 66 Thebe. The consensus is that labour is there, but labour for arable farming will not be provided unless it can be paid for.

As said in chapter two there are many activities besides arable farming that compete for resources. In Table 13 an attempt is made to order a few of them according to farmers priority when allocating resources. The ranking is based on observations and discussions with farmers.

Table 13. Order of Priority in Resource Allocation to Different Activities.

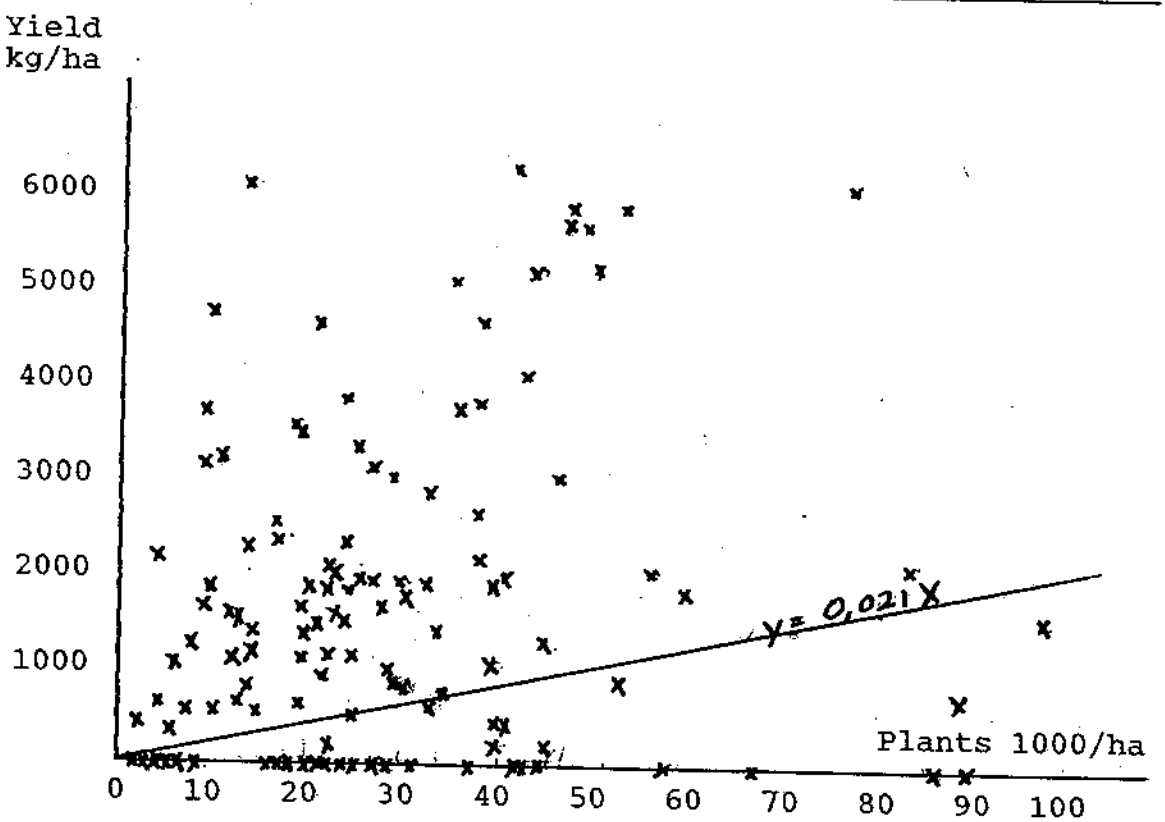
1 Formal employment
2 Casual employment
3 Cattle
4 Arable farming

The reason to that arable farming do get the amount of labour it does, is that most farmers do not have the possibility to allocate more resources to activities with higher priority. Even when asking one of the most successful arable farmers what he wants to do, the answer is that he wants more cattle. Another example is that even a small possibility for formal employment is ranked higher than arable farming. Men migrates to urban areas looking for employment even during the cropping season. Farmers invest in their children's education, not with the aspiration to make them better farmers, but with the hope that they will be able to obtain employment. With this background it is not surprising that the adoption of improved arable practises is slow, especially if they demand additional resources. Farmers aspiration is not to develop arable farming, since by experience they do not believe that arable farming can meet their needs.

Another important factor to explain why farmers do not adopt methods that are supposed to be of benefit to them, is that often farmers do not face the same economic relationship as

the new method is based on. For example many improved methods and new technologies investigated by researchers or disseminated by the extension service are carried out early in the cropping season. Rowplanting, harrowing or improved seed varieties are some examples. With harrowing and planting good seeds with a planter ensures a good seedbed, good germination and an improved stand establishment. All with the logical assumption that a good stand establishment will result in a better yield. Results from on farm trials show that often farmers do not have this relationship between plant population and yield. In figure 5 plantpopulations and yields from on farm trials in molapo fields are presented. Only trials that did produce any yield are included. Farmers have an even smaller relationship.

Figure 5. Plantpopulations and Yields, Molapo on Farm Trials




A regression for the data presented in Figure 5.(see appendix 3) reviels that there is a significant relationship between yields and plantpopulations. However only six percent of farmers variation in yield is caused by variations in plant population. 94 percent of the variation in yields is caused by other factors. Farmers can thus expect very little benefits from their efforts, even though they manage to obtain optimal plantpopulations.

## 3.2 Human Constraints

The human resource ie the farmer is or should be the focus in any attempt to develop arable farming. Following this the extension service is the key to any development. Some of the human constraints are described, as are the problems in overcoming these constraints. One should not be surprised that a farmer do not buy or use a planter, when he has never seen one. What is needed is obviously to show him a planter and how to use it. To develop a new planter is of little use.

### 3.2.1 Lack of Self Confidence

The biggest constraint regarding farmers is their general lack of self confidence, or lack of ability to see how they can improve their own situation. This lack of self confidence expresses itself when farmers are asked, what can they do to improve arable farming or their living condition. The answer is that there is nothing they can do, or that the government should tell us.

One example is fencing. One of the major factors that hampers the use of government subsidies for fencing, is that there are very few persons in the area that have experience in building fences. A farmer that have received his fencing material often has to wait for months before he can get help from such a person. Why farmers wait instead of putting up the fence themselves is hard to understand. When asked farmers reply that they do not know how to build a fence. Considering their general experience in carpentry and in building traditional houses, every farmer could after studying a proper fence, build his own fence, if he just gave it a try.

A second example is wells. Everyone in a village benefits from a well, either close by the village or at the land areas. The men would benefit by not having to trek the animals far away for watering, and the women would not have to spend hours every day to fetch water. In many villages wells are dug, but not until someone from outside suggests it and points out the benefits with a well.

A third example is seeds. Farmers often complain that they can not obtain the seeds they want. Seeds like groundnuts or juggobeans that are not issued by the government. They are clearly prepared to pay for seeds, as was proved this season when the local Coop sold seeds. What is amazing is that none of the farmers, most of them members of the Coop, have requested that the Coop should sell seeds.

### 3.2.2 Crop Husbandry

Farmers knowledge in crop husbandry is another important constraint. Farmers have without doubt many years of experience in arable farming, but their knowledge is generally poor. By experience farmers know that too many plants often causes crop failure, which is correct. Their explanation is however wrong. The general belief is that the air between the plants is getting bad and the plants suffocate. In the traditional arable farming this explanation is adequate, since it serves the purpose of not planting with to dense plant populations. If irrigation or the use of fertilizers are introduced this explanation is no good any longer. Farmers experience regarding plant population has no application on, for example irrigation, because they often have wrong explanations to their experiences.

Early ploughing is recommended by the extension service. Many farmers are reluctant to follow the advice, since they believe that early ploughing promote weed growth.

The clearest example of poor knowledge is provided when studying the ploughing operation. The plough is the only arable implement that is widely adopted. It is then alarming that it is rare to see a farmer that knows how to plough properly, or understands the need to keep the plough in a good condition. Most ploughs have their mullboards full of soil during the ploughing operation. The effect is that the soil is not turned, it is just shuffled around and disturbed a bit. The common plough is a ten inch plough, farmers often plough with fifteen or even twenty inches between the furrows. The result is that weed control is very poor, which is serious since weeds are one of the major problems in molapo fields. Furthermore the animals have to pull a lump of earth through the soil, instead of a plough that cuts through. That those animals only can plough for a few hours a day, before they are exhausted, is not surprising.

The extension service recommend farmers to buy rowplanters, and also give subsidies to farmers who want to buy a planter. If farmers started to buy planters and to use them, it is a great risk that this would be counter productive. To use a planter successfully some knowledge and training is needed. The field assistants working for the project, have several years of experience in the use of rowplanters. Despite this, several mistakes were made this season. Mistakes that were not discovered until the crop had germinated. If this would happen to farmers, it is likely that they would regret that they listened to the extension service.

It is a general belief that the fact that farmers do not adopt rowplanting or other extension advices, shows that these methods or technologies are not good enough. The result is more research into better methods and technologies, that farmers will hopefully adopt. The answer is that the majority

of the farmers have never seen a rowplanter or have had it demonstrated to them. Farmers have never had the opportunity to show what they can produce with existing knowledge or technologies, simply because these technologies have never been forwarded to the farmers.

### 3.2.3 Extension Service

The above examples serve to highlight the need for educating farmers, before any development can be expected. They also show that the present training of farmers is inadequate.

To disseminate improved methods and to educate farmers in the use of them is the responsibility of the Department of Field Services. It is obvious that the department has not been successful. This is further stressed when farmers knowledge about government support programmes is considered. In Table 14 farmers knowledge about support programmes is presented.

Table 14. Farmers Knowledge about Government Support Programmes*, Percent of Total.

| | Male | Female | Total |
|---|---|---|---|
| ALDEP | 22 | 10 | 16 |
| AE 10 | 20 | 7 | 14 |
| FAP | 12 | 4 | 8 |
| SLOCA | 15 | 5 | 10 |
| NDB | 19 | 7 | 13 |

* See abbreviations

(Compiled: from ADN Technical Report No.I)

As can be concluded from the Table the extension service is not able to forward information to farmers, and especially to female farmers. Most farmers familiar with the support programmes claim to have received their information through the radio.

To explain why the extension service has failed, and will continue to do so, is best done by a look on the work the local extension personnel is supposed to perform.

Within the CFDA there are more than 2 000 farmers. In the area there are three Agricultural Demonstrators (AD), each one serving about 700 farmers. Farmers that are spread over large areas, and the majority of them are illiterate. To his

help the AD has his education and if lucky a tape measure. If he can afford he might buy a motor cycle, but that is up to him.

The AD is supposed to carry out an astonishing number of tasks, within a wide range of disciplines. He is supposed to instruct and assist farmers with:

- Animal husbandry
- Crop husbandry
- Horticulture
- Grain storage
- Group formation and management
- Irrigation practices
- Fencing
- Beekeeping

The AD has to inform farmers and to process all applications regarding following government programmes:

- ALDEP
- ARAP
- AE 10
- SLOCA
- FAP
- Drought relief
- NDB

In addition to these activities the AD shall keep farmers' record cards of all farmers within his extension area. He shall implement and manage demonstration plots and organize demonstration days. He shall assist and work with the Landboard, 4-B, Village Development Committees and Village Extension Teams. He shall attend monthly, quarterly and yearly meetings. At each meeting a written report has to be presented, stating the progress for each single activity and plans for the future.

The above list of the ADs duties is not complete. A study regarding ADs perceived competencies, (see ATIP working paper 6) consisted of 102 competencies categorized under 13 subject

areas. It is no wonder that ADs perceived competencies was quite low.

The ADs are supposed to be supervised and assisted by the District Agricultural Supervisor (DAS). The DASs are however fully occupied with distributing money and implements to farmers and to collect downpayments. These revenue activities take more than their full working time.

The appraisal of extension staff is based on how many ploughs, planters, fences etc that have been sold in their area, or how many thousands of Pula have been paid to farmers, or how much seeds and fertilizers have been distributed. This activities are logistical activities rather than extension activities. They do not improve the arable knowledge of farmers and thus not their ability to increase production. ADs complain that they supply all these inputs to farmers, but they have no time in demonstrating how to use them.

Whit this background it is not surprising that new technologies never reach the farmers. There is in fact no extension carried out. Not only does this situation prevent arable development, it does also create very low working morale within the department of Field Services.

## 3.3 Social and Cultural Constraints

Social and cultural constraints are common, and by their nature nearly impossible to measure. The list of constraints presented here should not be considered as complete. It is a list of constraints that have been observed rather than measured. The importance of these constraints regarding arable development is hard to estimate. One thing is however clear that they do have implications on arable development and extension work.

To begin with some examples or case studies, are given about occurrences, that at first sight are difficult to understand or explain. The examples are followed by tentative explanations. It is of interest that the examples are authentic. At the time of observation they were not understood, and appeared to be illogical or irrational. It is later on during discussions with initiated persons and with the help of the work of mainly three anthropologists that the listed examples could be explained and hopefully understood. The anthropologists are. Tom Larssen who studied the Hambukushu in Shakawe. Alistair Sutherland who studied the land tenure in the CFDA but mainly studied the Yei on the western side of the Delta. Inge Tvedten who studied the Yei on the eastern side of the Delta.

### 3.3.1 Examples

A) Horticultural plot in Etsha

Two men, both Hambukushu made an attempt to start vegetable production on an island in the Delta, just east of Etsha 6, the main village in the area and thus the main market. They had some education and they both had employment, and thus some cash they could invest. They invested considerable amounts of labour and money, in clearing and fencing the plot. They planted, the plants germinated and developed well. When needed the plants were irrigated using a bucket. Nice vegetables were produced, and they were just ready for harvest when something started to go wrong. Whenever vegetables were ready for harvest, the plot was destroyed by livestock. The gate had been opened and cattle chased into the plot. This happened again and again, until the two men gave up their idea of producing and selling vegetables.

B) Ploughs in Tubu

The government assist farmers to obtain ploughs and other arable implements, through the Arable Lands Development Programme (ALDEP). ALDEP provides an 85 percent grant when a farmer buys an arable implement. In Tubu this appeared to help farmers to overcome a real bottle-neck in arable production. Many farmers were unable to plough and plant at the optimal time, since they did not have ploughs and had to wait until someone with a plough could help them. With such a big subsidy on ploughs every farmer could afford to obtain his own plough. When information about ALDEP was forwarded to the community, the community leaders promptly used the programme to obtain new ploughs. Most of the community leaders already had ploughs. Some of them even bought planters and harrows. It was apparent that to own a planter or harrow was a question of status, even though it later turned out that they have never been used. The future looked good for ALDEP, since surely the farmers would follow the example set by their leaders. Then the community leaders began to warn farmers in the area not to obtain ploughs or other implements through ALDEP, because if they did so the government would take their harvests. The community leaders were clearly telling the farmers something that they new was not true, why?

C) Eight oxen when ploughing

Whenever someone new to the area observes a farmer in the molapo area ploughing his field, the first question is. Why does he use so many animals? When ploughing a farmer in this area never uses less than six animals, more common is to use eight or ten animals. In surrounding areas farmers normally uses two oxen or sometimes four if the animals are week. It

is obvious that to plough with so many animals is labour demanding and inefficient. Two men are needed just to keep control over the animals. To turn with ten animals is quite an operation, especially since the fields are generally small. To plough straight is almost impossible. When asked why he ploughs with so many animals a farmer will say that the soil is very hard or that there are so many weeds. That other farmers on similar soils can plough with only two oxen they deny. It is however obvious that to plough with so many animals rather hamper the work than to improve it.

D) Not interested in higher yields

One of the project farmers appeared not to be interested in obtaining a good harvest. On this farmers field a trial was carried out, a control plot that was broadcasted, and a trial plot that was rowplanted. Both plots had germinated very well and there was a well established crop. The field was properly fenced with a bush fence. Everything was there to ensure a good harvest. The problem was that the crop was under serious competition with weeds. Both the farmer and his wife were living at the field and obviously had the time to weed. During a visit the farmer confirmed that surely there would be a good harvest if weeding was done. Still he did not weed, and predictably a very mediocre harvest was the result.

E) NDB loans

At one time two officers from the National Development Bank (NDB) toured the area trying to persuade farmers to repay their loans. They were heavily attacked, verbally by one farmer who had obtained a loan and never repaid anything. How could they expect him to repay more than what he borrowed. The farmer was very upset that the NDB wanted to profit on him instead of helping him. When he obtained the loan he was told that NDB was there to help farmers. On each payment advice he get, there are interest charges, and that, he would never pay.

### 3.3.2 Explanations

A) Horticulture plot in Etsha

There are two possible explanations to why the attempt to produce vegetables was sabotaged. The first explanation has its background in the very strong traditional beliefs amongst the Hambukushu. Witch craft and other superstitions are always present. A missionary who lived in the area for some years said **"whatever a Hambukushu intends to do, he first consider possible effects this might have, on what we call witch craft"** These strong beliefs are confirmed by T. Larssen 1970. The traditional belief with bearing on this example, is

the growing spirits. It is the growing spirits that determine if a farmer will obtain a good harvest or not. If one farmer is remarkably more successful than his neighbours, this is achieved by him using witch craft in order to draw the growing spirits from his neighbours fields to his own. The neighbours can only protect their crops by destroying the crop of the offending farmer.

The second explanation is the very strong community ties in the Hambukushu society. This was expressed by the VDC chairman in Etsha at a meeting, as quoted **"We Hambukushu need and want development. But it must be development for everyone. No Hambukushu should try to achieve development by himself for his own benefit"**. The two men did try development on their own, and it is possible that the destruction of their crops was a signal to that effect.

B) Ploughs in Tubu

To own a plough in this area is not a question of affording to buy a plough. A farmer that owns a plough has earned the communities recognition as being, what Sutherland call a good neighbour. Such farmer ought to own a plough, and assist other farmers with the ploughing operation. In this way one of the most important arable resources is under control of the community leaders: To quote Sutherland **"Hence by controlling ploughing, neighbours are able to impose a collective control on the surplus production of individual households."** The plough, is the tool of the local sanction system, to control community members that for some reason do not behave in a way that the community demand. This tool was in the hand of the community leaders, and gave them considerable power. In warning other farmers from obtaining ploughs, the community leaders tried to protect the sanction system and their own power.

C) To plough with eight oxen

To use eight oxen when ploughing has nothing to do with necessity or efficiency. A proper span of oxen should consist of at least six animals, that is a requirement from the community. If a farmer would plough with less animals he would be ridiculed by his neighbours. In years when there is a general shortage of animals it can be accepted to plough with four animals. The purpose is again that the majority of farmers should not be able to plough on their own. If they have to rely on neighbours in order to plough, they also have to conform to the communities standards. To quote Sutherland **"A ploughing partnership is perhaps the most critical and regular form of cooperation between households: the form which is the clearest expression of a social sanction against household autonomy in production."** Sutherland also predicts that if the arable system develops towards a more commercial

attitude, the farmers will be more concerned about the efficiency of the ploughing operation.

D) Not interested in higher yields

Behind this farmers reluctance to weed his plot is the traditional land tenure system. In the molapo one can distinguish between three land control positions, title holders, recipients and borrowers. (see I.Tvedten 1985) The system is controlled by the farmers who are title holders to land. They have the responsibility to distribute land to other farmers within the area. A title holder can give away land, and thus making a farmer a recipient. The recipient have the right to use the land as long as he want, and he can lend land to other farmers. More common is that the title holder lend out land. The borrower can use the land as long as the title holder allows him to use it. The title holder has the right at any time to take the land back, or reallocate land. He can however not take land back when there is a growing crop in the field. In this area there are one title holder, one farmer who has been given land, and eleven farmers who borrow land from the title holder.

At one discussion with this farmer he opened his heart after a couple of hours. He was obviously in a bad situation. When he borrowed his field, it was often to wet to plant at a proper time, and if there was an early flood his field was flooded before the crop was mature. During later years the area has dried up, and his field is now one of the few fields with adequate moisture. What worries him is that if he obtains very good yields for a couple of years, the title holder will take the land back and give him another, not so good piece of land. He had already had a dispute with the title holder. Next to the field there is an island. The farmer had cleared an area on the island, with the intention to plant sorghum under rainfed conditions. This land had never been cultivated before. When the title holder saw this, he said that this land he could not use since he, the title holder, had never lent it to the farmer. The farmer had to leave the cleared land unplanted. This farmer risk to loose his land if he happens to produce to much on it.

E) NDB loans

The explanation to this farmers reaction to the fact that the NDB charged interest is found in the traditional credit system. The traditional credit system is not very large in scale, since the farming system is a very low input system that does not require cash. When loans are asked for or granted it is usually between persons with some kind of relationship, to grant a loan is a recognition of the relationship or of the person asking for the loan. Security for loan is usually cattle, a person with many cattle can be

trusted to borrow more money since his ability to repay is considered to be high. The perhaps most unusual is that in the traditional credit system, interest does not exist. If you borrow 100 Pula for one year, of course you pay back 100 Pula. It is understandable that this farmer was upset that the NDB who is supposed to assist farmers, charge interest. He might have been able to borrow the money locally and no interest would have been required.

## 3.4 Summary

The social or cultural traditions that have most significance on arable development is the traditional sanction system and the land tenure system.

### 3.4.1 The Sanction System

This informal sanction system is used not to punish criminal offenders. It is a system in which the community can apply pressure on members that do not behave in a neighbourly way or do not conform to community traditions. This system is based on, and thereby controlled by those who posses arable production resources. The most important arable resources are land, droughtpower and ploughs. It is obvious that if everyone have independent control over these resources, the sanction system would collapse. Those who control the system would then loos their power in the community, and it is of course in their interest to protect their position. As mentioned the system is based on resource control, and to protect the system the present resource control must be conserved.

Most arable support programmes are aimed at resource poor farmers. Since it is recognized that control over resources do play an important role regarding arable productivity. To improve the poorer farmers potential productivity the support programmes aim at assisting these farmers to obtain arable implements etc. It is obvious that the objective of these programmes are completely contradicting to the aspirations of the power holders in the community.

Sutherland stresses the need for these sanction systems in a community with very high interdependence. All members of the community depend on each other for survival. If anyone do not conform this could threaten the whole community. the power holders had the responsebility for the community, how much cattle and lands were needed to feed everyone under his responsebility. Today a major part of this responsebility has been taken over by the government. The interdependence that was so vital is now diminishing. The power holders are relieved from their responsebility but they remain with their power.

### 3.4.2 The Land Tenure System

The traditional land tenure system is recognized by the land board. Thus the principles of the national Tribal Land Act of 1968, has had very little influence on the land tenure in the molapo areas.

The title holder has total control over arable land within his area. Farmers who depend on borrowing land, the majority, are completely in the hands of the title holder. The title holder have certain responsibilities. It is his responsibility to allocate land to the members of his community. A person who has his land taken away from him has a traditional right to be allocated another piece of land. If he is not pleased with the new land he is free to go to another title holder and ask to borrow land.

A. Sutherland 1981, points out the advantages with the traditional land tenure system. The advantage with the system is its flexibility. With an ever changing flood pattern of the Delta it is important that the land tenure system is flexible. He further stresses the fact that the title holders are recognized as allocators by the local people. Title holders are, in practise usually older men who have displayed appropriate allocation skills. What he does not express as clearly is that the right to allocate land is not acquired, it is inherited, and by definition feudal. Sutherland recommends that the present land tenure system should not be interfered with by the Land Board. He states **"Thus, a registration policy in molapo areas could significantly affect the equity of landholdings."** His recommendation is surprising. What can be more unequal than that one person controls huge areas of arable land, that other farmers are depending on for their subsistence. I.Tvedten says about the land tenure system **"... molapo tenure is characterized by inequality in terms of both control of land as a means of production, the legal status of holdings, the condition of transfer, and ultimately access to ploughing land concerning size and quality which by no means reflect individual needs."** Sutherland rightly stresses the need for molapo farmers to be able to have access to land at several sites. The flexibility is important, but the present flexibility is completely on the title holders terms.

The dependence on the title holder by other farmers, and the title holders power is enormous in a society that traditionally is arable. The title holders hold an enormous bargaining power. In the Matsaudi area title holders use this power to obtain labour for their own arable activities.(see I.Tvedten 1985) Farmers who are allocated land by the title holder, are required to work on his fields. This has not been observed within the CFDA, but the potential is certainly there.

The traditional land tenure system have serious implications on farmers aspirations and arable development. Much hope is put on the arable sector for economic growth, and certainly there is potential for this in the area. The Government has adopted development through small scale farmers. For such a development to take place there are several requirements. Mentioned earlier is education of farmers, access to resources and infrastructure. Education of farmers and for them to acquire resources depend on farmers aspirations to involve themselves more into arable farming, and by doing so being more dependent on arable farming. A farmer who does not even have secure access to land, but is depending on borrowing land, is hardly interested in depending even more on arable farming. He is more likely to aspire to depend as little as possible on an activity over which he has so little control.

## 4 Marketing

In both ADN Phase I Reports (1981 and 1983) marketing of agricultural products are listed as major constraints to agricultural production. Problems that are mentioned are:

- Lack of formal markets
- Poor price information/ setting
- Low prices
- Lack of agricultural inputs, mainly seeds

For 1984 the ALDEP regional manager reported that lack of availability of implements and fencing material reduced the utilisation of ALDEP within the area.(ALDEP Regional Manager Report 1985)

Seed supply is still a major problem to farmers. The government do distribute seeds free of charge. This source can however not be relied upon. Farmers have by experience learned that often the seeds are distributed too late, and they receive wrong seeds.

### 4.1 Agricultural Inputs

The availability of agricultural inputs have improved considerably during the 1980s. Shortage of agricultural commodities can generally not be regarded as a major constraint to agricultural development, with the exception of seeds. Prices must be considered as reasonable, and what is available is limited to farmers demands. In section 6.2.1 farmers ability to see how they can improve their situation was mentioned. This have implications on supply of agricultural inputs. Farmers do not normally voice their demands. If something is not available it isn't, that this situation can not be changed, is often not recognised.

#### 4.1.1 Livestock Inputs

With the opening of a Livestock Advisory Centre in Gomare 1981, the availability of tools, drugs etc. was improved tremendously for livestock owners. The LAC, stocks drugs and vaccines for the most common diseases, for cattle as well as smallstock. Tools, injection equipment etc is available. Fencing material, mineral supplements and fodder are sold, all to reasonable prices. In addition to this the staff at the LAC are well trained, and provide advices and assist farmers with treatments, free of charge.

The 1985 survey revealed that use of drugs and generally the management level of livestock is considerably lower in the Etsha area than in the southern part of the CFDA. One explanation to this could be the distance to the LAC depot in Gomare. The local Coop have for quite some time tried to provide drugs and vaccines. They do however depend on some cooperation from the Department of Veterinary Services. Unfortunately this cooperation has never taken place.

### 4.1.2 Arable Inputs

The main provider of arable inputs is the Department of Field Services. Why this situation has occurred in the area is hard to explain. Arable implements are available at the three Coop branches situated within the CFDA and at the private store in Gomare. In fact Field Services purchase most of the implements, they forward to farmers, from the Coop. Besides arable implements the Coop also stock seeds that are not available through the Government seed distribution programmes. Seeds like groundnuts, cowpeas, millet and vegetable seeds.

Experience show that the local Coop is perhaps better suited to estimate and to provide seeds, demanded by farmers. Of course the Coop can not stock seeds that are provided by the Government. If the Government seed should happen to arrive on time, the Coop would not be able to sell its seeds. If demand for other arable inputs should arise, the Coop would have no problems in meeting such demand. The fact that seeds are provided by the Government, make it impossible for Coops and local traders to predict demand for seeds, and thus they don't stock seeds like maize or sorghum. The Government seed distribution programme limits the amount of seed for each farmer. Farmers that need additional seed can not buy seeds since the stores do not sell it.

### 4.1.3 Summary

In the past the supply of agricultural inputs was considered to be inadequate and a major constraint to agricultural development. The Government tried to overcome this problem by setting up LAC depots and to provide farmers with various arable inputs. To a big extent this has been successful. Farmers do generally not have problems in obtaining agricultural inputs. In fact the low level of sales of agricultural inputs, now when they are available, indicates that lack of agricultural inputs perhaps never was the major constraint, it was believed to be.

The non Government sector has developed considerably during the past years. This development has taken place thanks to Government policy and investments. Today the situation appears to have changed. The private sector (including

Cooperatives) is able to provide agricultural inputs, and would probably do this better than the public sector. Development has made it unnecessary for the Government to provide these services, and the Government should take advantage of this development. To rely more on the private sector would give a number of advantages:

- The presently overloaded extension service would get more resources available for extension activities,and thus improving farmers potential to benefit from extension advices and to utilize agricultural inputs that have been made available.

- Considerable savings of Government funds. The low turnover at the LACs hardly justify the costs for depots and assistants, when these services can be provided by local traders.

- Provision of inputs would be handled by people and organizations that are trained in, experienced with and live by providing what customers demand.

- Local traders would be more suited to meet demands that are specific to their area. They would be able to offer a greater selection, of for example seeds than what is possible for the Government. Local traders would also be able to meet new demands or adjust to changes in demand faster than the Government.

- The private sector would be strengthened since it would be able to increase its turnover. This is likely to increase private investments in rural areas.

## 4.2 Agricultural Output

The possibility for farmers to sell their agricultural products has likewise improved considerably, both for livestock products and arable products. In 1984 the local Coop started to purchase grain from farmers. In 1981 the Botswana Livestock Development Corporation (BLDC) started to buy cattle in Nokaneng on a regular basis. That especially the arable sector is still mainly a subsistence sector does however result in few farmers actually utilizing the improved market. The drought to a great extent explain this. With the general shortage of grain, few farmers have actually had anything to market. Those who have had grain to sell have been offered higher prices on the traditional informal market.

### 4.2.1 Marketing of Livestock Products

Farmers possibilities to sell cattle has improved tremendously. From being dependent on traders who visited the area in order to sell cattle, farmers can now sell direct to BMC in Maun, or to the BLDC when they buy cattle in Nokaneng. The local market is however of great importance for cattle, but also for other animal products like goats, chickens, milk, etc. In Table 15 percent of farmers who sold different animal products is presented. The figures refer to percent, of for example goat owners who sold goats.

Table 15. Farmers who Sold Animal Products During 1984. Percent.

| | Molapo farmers | Dryland farmers | Total |
|---|---|---|---|
| Cattle | 75 | 28 | 53 |
| Goats | 30 | 26 | 28 |
| Chickens | 16 | 28 | 22 |
| Eggs | 9 | 12 | 10 |
| Milk | 36 | 23 | 30 |

(Compiled from: ADN Technical Report No.I)

The perhaps most important information in Table 14 is that there is a more commercial attitude towards livestock, especially cattle. This is very obvious regarding the molapo farmers. Dryland farmers do not sell cattle to the same extent. Their main interest in cattle is to use them for arable production. They have little experience and tradition in cattle rearing, and mainly value cattle for their use in arable production. What is interesting is that female headed households to a higher degree market products from their livestock than male headed households,(see ADN Technical Report No.I) if this is from necessity or from a more commercial attitude is hard to say.

Table 16. Sales of Animal Products within the CFDA 1984.

| | Molapo area | Dryland area | Total |
|---|---|---|---|
| Cattle (heads) | 3 000 | 300 | 3 300 |
| Goats (heads) | 900 | 500 | 1 400 |
| Chickens(heads) | 450 | 900 | 1 350 |
| Eggs (eggs) | 20 000 | 15 000 | 35 000 |
| Milk (litres) | 100 000 | 125 000 | 225 000 |

(Source: ADN Technical Report No.I)

The total estimated value of animal products that are traded is for the molapo area, Pula 500 000, and for the dryland area, Pula 100 000. Over 90 percent of the total value, originates from cattle. All products except cattle are sold on the local informal markets. The importance of the local market is high, also for cattle. In Table 17 estimated, local consumption of goats and cattle is presented.

Table 17. Cattle and Goats,Slaughtered for Local Consumption.

| | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|
| Cattle | 640 | 750 | 750 | 830 |
| Goats | 530 | 880 | 1 010 | 1 180 |

(Source: Kgotla Records for Gomare,Nokaneng,Habu and Etsha)

About five percent of slaughtered cattle and one-third of slaughtered goats, are for social events, the rest is sold at the local meat trees or butcheries. What is interesting is that roughly twenty percent of cattle off take is sold on the local market. The local market is important since it offers the opportunity to obtain cash immediately, and the prices are generally high. It is also the only market for smallstock and other animal products. In Table 18 prices for cattle and goats obtained on the local markets are presented.

Table 18. Average Prices and Total Values, in Pula, Obtained for Cattle and Goats on the Local Markets.

| Year | Goats P/Head | Goats Value | Cattle P/head | Cattle Value | Total Value |
|---|---|---|---|---|---|
| 1986 | 32 | 32.000 | 186 | 139.500 | 171.500 |
| 1987 | 44 | 52.000 | 216 | 179.000 | 231.000 |

It is interesting to see that the local market for goats was increasing twice as much as for cattle, in value. If the explanation is the very severe effects the drought had on cattle during 1987, or if it is a trend remains to be seen. It should be noted that there is no other market for goats, and the number of goats has been increasing, as has the interest in goats, due to the prolonged drought.

### 4.2.2 Marketing of Arable Products

Until the Coop started to purchase grain in 1984 there was no formal market available to farmers in the area. The nearest Botswana Agricultural Marketing Board (BAMB) depot is situated in Maun, more than 200 km away on bad roads. With the big distance and non existing public transports the BAMB depot in Maun, have had no impact in the area. Informal markets was the only available outlet for surplus arable production. Traditionally the Herero who are pasturalists have bought their arable products from the Hambukushu and Yei. This market is still quite important. When the Coop started to purchase grain at fixed prices, (BAMB price Maun), the farmers have benefited in two ways. They now know, or will learn that they can sell all their grain, even in years when harvests are very good. Earlier farmers have not been able to sell all their surplus production, in years when most farmers have had good yields. This fact result in that to plant large areas have been meaningless. There is no point producing surpluses that can not be sold. Secondly farmers benefit from a fixed price. Farmers have always been at a disadvantage when negotiating prices, since they have had very little idea about the market situation. (see Phase I Report 1981) Today farmers have a minimum price, which they can use in good years. During drought years the informal market is likely to offer higher prices than the Coop.

Arable farming is still mainly a subsistence farming system. Farmers produce for their own needs and not intentionally for selling. When surpluses are produced, they might be sold, given to relatives or most common used for beer brewing. In the Phase I Report 1981, between 80-90 percent of farmers reported that they never or rarely sold grain. In the 1985 survey farmers were asked if they sold grain from the

1984/85harvest.

Table 19. Percent of Farmers that Sold Grain from the 1984/85 Harvest. And Estimated Quantities.

| | Molapo Farmers | Dryland Farmers | Total |
|---|---|---|---|
| Percent | 11 | 32 | 20 |
| Tonnes | 17 | 25 | 42 |
| Value Pula* | 5.100 | 6.500 | 11.600 |

* Molapo area Coop price maize P 0.30/kg
Dryland area Coop price millet P 0.26/kg

(Compiled from: ADN Technical Report No.I)

Table 19 raises two interesting points. Firstly that there are three times as many farmers that sold grain in the dryland area than in the molapo area. This could be an effect of easy access to the market, since during that season the Coop only bought grain in Etsha 6. The importance of easy access is confirmed by the fact that in Etsha 6 and Etsha 8, villages that are within two kilometres distance from the grain market, almost 50 percent of the farmers sold grain. In Etsha 13 and Etsha 12, ten kilometres away and very bad road, only fourteen percent sold grain. Secondly, farmers that do sell grain in the Molapo area usually sell larger quantities. This could be an effect of the very unequal control over arable land. (see section 3.4.2)

During the first year the Coop purchased grain, more than two hundred tonnes were bought. Most of this grain was later sold in the area. It appears that farmers sold grain that they needed for own consumption, and it was in fact not surplus production. When they bought the grain back they had to pay P 21 for a bag of millet, that they had sold for P 14. In Table 20 Coop purchases of grain from local farmers is presented.

Table 20. Coop Purchases of Grain from Farmers in the CFDA by Season. Volumes and Purchase Values.

| Volume tonnes | Season 1983/84 | 1984/85 | 1985/86 | 1986/87 |
|---|---|---|---|---|
| Maize | 0.4 | 0 | 0 | 0 |
| Millet | 187.3 | 26.8 | 42.4 | 0 |
| Sorghum | 19.0 | 0.9 | 4.0 | 0 |
| Total | 206.7 | 27.7 | 46.4 | 0 |
| **Value Pula** | | | | |
| Maize | 70 | 0 | 0 | 0 |
| Millet | 37 464 | 6 968 | 12 330 | 0 |
| Sorghum | 4 932 | 288 | 1 226 | 0 |
| Total | 42 466 | 7 256 | 13 556 | 0 |

(Source: Etsha Coop Grainmarket)

No grain was bought from the 1986/87 harvest. That season was the worst during the drought, and very few, if any farmers had any grain for sale. In 1985/86 an additional fifty tonnes was bought from farmers outside the CFDA. The small quantities of maize that has been purchased, indicates that molapo farmers have so far not utilized this new marketing possibility. This is likely due to the distance to the market, and that during drought years the informal markets demand is higher than what is for sale. A rough estimate is that the informal trading of grain represent at least as high value as the formal market. During the four seasons the Grain Market has been operating there has been no actual export of grain out of the area.

## 5 ADN Agronomic Work Programme

The Agronomic work programme has consisted of mainly two different approaches for the different farming systems in the area. The different approaches developed from identified constraints. The identified constraints in molapo farming was, difficulties in crop establishment and severe weed infestation.(see ADN technical Report No.3) In dryland farming the constraint was identified to be limited ability to increase cultivated and planted area.(see ADN Technical Report No.4) Testing and evaluation of new technologies has mainly been done through on farm trials, and to some extent through on station trials.

### 5.1 Molapo farming

Major constraints to molapo farming were identified to be problems with crop establishment and weed control. In addition to this it was realized that livestock caused considerable damage to crops. In order to overcome these constraints it was reecognised that improved seedbed preparations and improved planting techniques were needed. Improved seedbed was achieved with the introduction of harrows. To improve planting, different animal drawn rowplanters were tested. To control weeds it was recognised that more efficient methods was required since labour requirement for traditional weeding is very high. To control livestock is a problem since farmers are reluctant to erect fences. Farmers have to move their fields according to the level of the annual flood. They can therefore not use a fence for more than a couple of years. In Figure 6 the agronomic approach is summarised.

Figure 6. Agronomic Approach to Constraints in Molapo Farming

| Constraint | Action | Tested Technology |
|---|---|---|
| Poor crop establishment | Improve seedbed preparation | Harrow |
| | Improve planting techniques | Saffim planter<br>Sebele planter<br>Rowplanting by hand |
| Weed control | More efficient methods | Herbicides |
| Livestock | Moveable fences | Electric fencing |

5.1.1 Results on Crop Establishment

On farm trials were carried out in order to improve crop establishment. The trials consisted of a control plot where the farmer used his traditional broadcasting and ploughing, and a trial that was ploughed, harrowed and planted with a rowplanter. Other trials with the same control but where the trial was to plant the seed in every third furrow when ploughing. The results are presented in Table 21.

Table 21. Results From Molapo On Farm Trials 1985/86.

| | Seed rate | | Plant Population | | Germination |
|---|---|---|---|---|---|
| | kg/ha | S.E. | plants/ha | S.E. | % |
| Control | 23.6 | 1.08 | 22 960 | 13 540 | 38 |
| Trial | 15.1 | 1.08 | 25 830 | 22 080 | 60 |

(Compiled from: ADN Technical Report No.3)

There were no conclusions to be drawn from yield data.

The combined use of harrow and rowplanter has increased the germination rate with almost 60 percent compared to the traditional broadcasting. There is however no significant effect on plant population, thus it is not surprising that yield data were inconclusive. Farmers obviously compensate their lower germination rate by using more seed. Noticeable is farmers accuracy in estimating seed rates. Their variance in seed rates is the same as for the planters. It is also of interest that broadcasting has 40 percent lower standard error in plant populations than the rowplanted trials. This is quite a considerable difference, which indicates that even though planters increase germination rate quite considerably, the variation in actual plant populations is higher. There are two possible hypothetical explanations to this effect.

The planter does improve germination when the moisture conditions at planting depth are favourable. When the moisture conditions are unfavourable at planting depth, the planter has placed all the seeds at the same depth and the germination is very low. Broadcasting places seeds at various depths which result in that there are seeds germinating even though the moisture conditions at one depth are unfavourable.

During the 1987/88 season cutworm was a serious problem. It was very clear that rowplanted crops were much more damaged by cutworm than were broadcasted. On several sites the rowplanted crops were completely destroyed, while the broadcasted plot, in the same field, established a satisfactory plant population. There are two hypothesis to this. Firstly it is obvious that the cutworm follows the row, when in it. One can quite accurately estimate where the worm

is in the row, and dig it up. The second explanation is that a rowplanted crop have much more uniform germination in relation to time. The result is that if the cutworm is active all plants are at the same depth and at the same growing stage. In a broadcasted crop the worm have harder to destroy all plants since they are erratically spread. A broadcasted crop have plants of various growing stages when the cutworm is active, some seeds might not even have germinated yet and can not be harmed by the cutworm.

The increased germination is caused both by harrowing and by rowplanting. This is confirmed by the fact that fields that have been broadcasted, ploughed and harrowed, as was done during the 1986/87 season, had higher germination percent than fields that have only been broadcasted and ploughed. The germination percent is however not as high as when both harrow and planter have been used.(see ADN technical Report No.3) To obtain the 60 percent increase in germination rate a farmer has to buy a harrow and a planter. The implements are assumed to be used on five hectares per year. The partial budget is presented in Table 22.

Table 22. Partial Budget for Harrowing and Rowplanting. Per Hectare.

| Incomes:[1] | Pula |
|---|---|
| No Broadcasting 2 hours * 0.60 P/h | 1:20 |
| Seed 8.5 kg/ha * 0.65 P/kg | 5:50 |
| Total Income: | 6:70 |
| Costs: | |
| Harrowing 8 hours 1.5 pers * 0.60 P/h[2] | 7:20 |
| Planting 7 hours 1.5 pers * 0.60 P/h | 6:30 |
| Harrow[3] | 1:22 |
| Planter[4] | 1:75 |
| Total Cost: | 16:47 |
| Net profit per hectare | -9:77 |
| Return to labour per hour[5] | 0.17 |

(Notes see appendix 1)

In practise most farmers obtain their seed free from the government. The response from project farmers regarding rowplanters have been low when considering what they actually do. There are however a few of them that have bought their own harrows. With the harrow they obtain improved germination while at the same time they keep the broadcasting. With the planter they would obtain even higher germination rates, but at the same time they would face greater variations in plant populations.

### 5.1.2 Results Weed Control

The major part of the herbicide trials were carried out as on station trials although on farm trials were carried out during the 1986/87 season. The trials were not altogether conclusive, but do indicate that weeds can be controlled by herbicides in molapo soils.(see ADN Technical Report No.3)

The attraction of herbicides is the enormous labour saving the use of herbicides would result in. To weed one hectare by hoe, takes roughly 100 hours, while it takes about five hours to spray one hectare. A partial budget is presented in Table 23.

Table 23. Potential Partial Budget for Herbicides. Per Hectare.

| Incomes:[1] | Pula |
|---|---|
| No hand weeding 100 hours * 0.60 P/h | 60:00 |
| Total Income: | 60:00 |
| Costs: | |
| Spraying 5 hours * 0.60 P/h | 3:00 |
| Herbicides | 20:00 |
| Sprayer[2] | 7:60 |
| Total Cost: | 30:60 |
| Net profit per hectare | 29:40 |
| Return to labour per hour[3] | 6:48 |

(Notes see appendix 1)

As can be seen the return from the use of herbicides has the potential to give very high returns for molapo farmers as compared to hand weeding.

### 5.1.3 Conclusions

The work programme has to a large degree been based on the assumption, that maize have a close relationship between plant population and yield. (see ADN Technical Report No.3) There are however strong indications that molapo farmers do not have such a strong relationship.(see Figure 5.) The reason to that farmers do not have a clear relationship between plantpopulation and yield is the high level of risk they face. A priority must be to try and improve farmers risk situation so that they obtain a better relationship between plantpopulation and yields. The practical implications this have is to concentrate work on factors that causes problems later on in the cropping season. This would ensure that a farmer actually benefits from improvements carried out earlier during the season. In Figure 7 some important relationships and their implications for further studies are presented.

Figure 7. Agricultural Relationships and Practical Implications for Continued Studies.

| Relationship | | Topics to be Studied |
|---|---|---|
| Harvest | Food/Cash | Harvesting Methods<br>Storage Techniques<br>Markets |
| Plant Population | Yield | Crop Protection<br>Fencing<br>Pest control |
| Planting | Plantpopulation | Planting methods<br>Cultivation methods<br>Weed control<br>Seed quality |

The figure should be read from top to bottom. If a farmer do not have the relationship between harvest and food, he is obviously not going to benefit from fencing his field. He is going to have very little benefit from any improvements that are carried out before he faces a weak relationship.

Pests causes severe problems in the molapo. (see ADN Phase I Report, ADN Annual Report 1982/83) Together with livestock, pests caused half of recorded crop failures.(see Figure 2.) Monitoring and control measures of pests should be given high priority. Fences together with successful pest control would improve farmers relationship between plant population and yield considerably.

Rowplanting and the use of planters is an advice to farmers, and promoted by field services. Farmers are however slow or reluctant to follow the advice to use planters. The reason for this is clear, they manage to obtain the same plantpopulations by broadcasting, and broadcasting is more reliable than rowplanting. It is obvious that rowplanting as such does not offer farmers enough incentives to adopt the method. Rowplanting is however the requirement for mechanical weeding, and should be presented to farmers for that reason. During the 1987/88 season mechanical weeding was tested. Not on the farmers fields, since they were not rowplanted, but by farmers with their animals on a plot that was rowplanted by the project. These farmers had never seen or done mechanical weeding before, and neither had their draught animals. Still they weeded a quarter of a hectare in two hours. Additional weeding in the rows took one man three hours. When studying the potential for rowplanting in combination with mechanical weeding the implications are more promising, as presented in Table 24.

Table 24. Potential Partial Budget Mechanical Weeding. Per Hectare.

| Incomes: | Pula |
|---|---|
| No Broadcasting 2 hours * P 0.60/h | 1:20 |
| No hand weeding 100 hours * P 0.60/h | 60:00 |
| Total Income: | 61:20 |
| Costs: | |
| Harrowing 8 hours 1.5 pers * 0.60 P/h | 7:20 |
| Planting 7 hours 1.5 pers * 0.60 P/h | 6:30 |
| Cultivation 10 hours 1.5 pers * 0.60 P/h | 9:00 |
| In row weeding 15 hours * 0.60 P/h | 9:00 |
| Harrow | 1:22 |
| Planter | 1:75 |
| Cultivator[1] | 0:41 |
| Total costs: | 34:88 |
| Net profit per hectare | 26:32 |
| Return to labour per hour[2] | 1:10 |

(Notes see appendix 1)

For comparison harrowing has been included even though it is not required for mechanical weeding. Apart from labour saving the more efficient weeding is likely to result in reduced crop failures, since farmers are often unable to weed and crops fail due to weed competition.(see ADN Technical Report No.3) It should be noted that the reasoning is hypothetical. Molapo Development Project has however for a number of years carried out work with mechanical weeding under molapo conditions and according to their experiences mechanical weeding is feasible.

Mechanical weeding fall far short of chemical weeding in the budgets. Mechanical weeding do however not require as high cash expenditure as chemical weeding. In a basically subsistence arable system, with its general shortage of cash, farmers might be unwilling to save labour when it requires cash expenditures. Furthermore many of the tested herbicides are toxic. Most molapo farmers have a well in the field where they take water for human consumption. To spray the soil surrounding wells could lead to pollution of the water. Herbicides and other chemicals might in the end be necessary to use. Where other methods are possible, and mechanical weeding do appear to have a potential, this should be tried.

## 5.2 Dryland Farming

The level of management practised by the dryland farmers was found to be high. (see ADN Phase 2 Report) The major potential for increased production was found to be by increasing area planted. Different approaches was used with consideration to farmers draught power control. In Figure 8 the agronomic approach is summarised.

Figure 8. Agronomic Approach to Constraints in Dryland Farming.

| Constraint | Action | Tested Technology |
|---|---|---|
| Area planted | Increase area planted | Hoe Farmers<br>- Herbicides<br>- Jab planter<br><br>Oxen owners<br>- Cultivators<br>- Row planter |

Hoe farmers limitation to area planted was found to be the area that could be cleared from vegetation before planting. The labour requirement would be reduced considerably if herbicides could be used. Planting by hand as done by hoe farmers is the second limitation to planted area. The jab planter which is hand pulled or pushed was considered to have potential use.(see ADN Technical Report No.4)

Oxen owners limitation to area planted was found to be the area they could plough and plant after each adequate rainfall. Planting is done by hand into every third furrow behind the plough. If ploughing and planting could be separated, so that planting could be carried out independent of ploughing after a good rain, the area that could be planted after each rain could be increased. This was tried with the Sebele single rowplanter. Ploughing was considered to be over working the soil and other implements for cultivation were tested. A reversible pole plough, a tool frame and disc harrow were tested. Farmers borrowing or hiring oxen would be able to benefit from either technologies.

### 5.2.1 Results Herbicide Trials

The dryland fields are usually located quite some distance from water sources. To apply herbicides with conventional sprayers is therefore not feasible. A low volume sprayer that uses about 25 litres of water per hectare was tested. The labour requirement for clearing one hectare by hoe is roughly 70 hours per hectare. The time varies a lot mainly due to annual rainfall. To clear one hectare using herbicides takes about five hours per hectare. The partial budget is presented in Table 25.

Table 25. Partial Budget for Herbicides. Per Hectare.

| Incomes: | | Pula |
|---|---|---|
| No clearing | 70 hours * 0.25 P/h [1] | 17:50 |
| No weeding | 70 hours * 0.25 P/h | 17:50 |
| Total Income: | | 35:00 |
| Costs: | | |
| Spraying | 10 hours * 0.25 P/h | 2:50 |
| Herbicides[2] | | 20:00 |
| Sprayer[3] | | 1:22 |
| Total Cost: | | 23:72 |
| Net profit per hectare | | 11.28 |
| Return to labour per hour[4] | | 1:38 |

(Notes see appendix 2)

A hoe farmer increases return to labour for weeding five times with the use of herbicides. On average hoe farmers manage to plant 1.5 hectares during one season. The labour made available from the use of herbicides is 160 hours per hectare.

As the objective with new technologies was to make more labour available to increase area planted, (see section 5.2) it is of interest to see what increase of area planted is made possible by the use of herbicides. From Table 5 wee see that hoe farmers use 272 hours of labour per hectare. A hoe farmers on average plant 1.5 hectare a year, which gives a total of 408 hours per year. With the use of herbicide the labour demand per hectare is reduced to 112 hours per hectare. With the amount of labour required for 1.5 hectares in traditional hoe farming, a farmer can plant an additional 2.1 hectares with the labour made available by the use of

herbicides, giving a total of 3.6 hectares per farmer.

### 5.2.2 Results Row Planters

There were no significant yield increases from using rowplanters. This was also not expected since the objective was to increase area planted when the moisture conditions are favourable. Faster emergence was however obtained, this was appreciated by farmers and confirmed by collected data. (see ADN Technical Report No.4) The effect on reduced risk by faster emergence is hard to value and is therefore not considered in tables 26 and 27.

Table 26. Partial Budget Rowplanting Oxen Owners. Per Hectare.

| Incomes: | Pula |
|---|---|
| No third furrow planting 12hours *0.37 P/h [1] | 4:44 |
| Total Income: | 4:44 |
| Costs: | |
| Planting 7 hours * 0.37 P/h | 2:59 |
| Planter[2] | 1:75 |
| Total Costs: | 4:34 |
| Net profit per hectare | 0:10 |
| Return to labour per hour[3] | 0:38 |

(Notes see appendix 2)

The labour saving with rowplanting is partly a real labour saving by the faster planting with rowplanter compared to hand planting. It is also a saving of time when moisture conditions are adequate for planting. Traditionally both ploughing and planting is carried out at the same time, requiring a total of 24 hours labour per hectare at the time of planting. With the row planter the labour requirement at planting time is reduced to seven hours per hectare. The actual limitation thus becomes the total labour available. The combination of freed labour and timeliness, allow oxen owners to increase area planted from 2.5 hectares to 2.8 hectares.

Table 27. Partial Budget Rowplanting Hoe farmers. Per Hectare.

| Incomes: | | Pula |
|---|---|---|
| No hand planting 27hours * 0.24 P/h | | 6:48 |
| Total income | | 6.48 |
| Costs: | | |
| Jab planting | 15 hours * 0.24 P/h | 3:60 |
| Jab Planter[1] | | 1:53 |
| Total Cost: | | 5:13 |
| Net profit per hectare | | 1:35 |
| Return to labour per hour[2] | | 0:33 |

(Notes see appendix 2)

A hoe farmer obtains a return to labour for planting with the jab planter of Pula 0.32 per hour. It does not seem much but it is 33 percent higher return than when planting by hand with a hoe. The increase in area planted by reduced labour requirement is 0.7 hectares. For this group of farmers who can not make use of animal drawn implements it is quite a considerable increase of return to labour. One problem is that the jab planter have problems with measuring millet seed accurately.(see ADN Technical Report No.4) The latest model of the planter, manufactured by RIIC in Kanye do seem to measure millet satisfactory, at least the example tested by the project.

### 5.2.3 Conclusions

The total potential increase in area cultivated and planted for the different categories of farmers, with the tested technologies are presented in Table 28.

Table 28. Potential Effect on Area Planted and Total Yields by Tested Technologies.

| | Hoe farmers | Oxen farmers |
|---|---|---|
| Technology | Jab planter +Herbicides | Row planter |
| Area planted traditional | 1.5 ha/farmer | 2.5 ha/farmer |
| Potential increase | 2.6 ha/farmer | 0.3 ha/farmer |
| Potential area planted | 4.1 ha/farmer | 2.8 ha/farmer |
| Number of Farmers | 200 | 1 050 |
| Total area planted Traditional | 300 ha | 2 625 ha |
| Yield 250 kg/ha | 75 000 kg | 656 250 kg |
| Potential increase | 520 ha | 315 ha |
| Potential increase in yield 250 kg/ha | 130 000 kg | 78 750 kg |
| Total potential area planted | 820 ha | 2 940 ha |
| Total potential yield 250 kg/ha | 205 000 ha | 735 000 ha |

Of the total potential increase in area planted, 835 hectares, 420 hectares is the benefit of the use of herbicides and 415 hectares is the benefit if rowplanters. One conclusion from this is that oxen owners also should use herbicides, they would then be able to increase area planted much more.

As can be seen that the use of rowplanters do have considerable effect on potential area planted, but have marginal effect on return to labour, at least for the majority of farmers. A great benefit from rowplanting is for farmers with draught power the possibility to practise mechanical weeding. Mechanical weeding have several advantages. It offers labour savings with less cash requirements than chemical weeding requires, it is an alternative to introduce herbicides to mainly illiterate farmers. In Table 29 the potential benefits from mechanical weeding are presented.

Table 29. Potential Partial Budget Mechanical Weeding Per Hectare.

| Incomes: | Pula |
|---|---|
| No third furrow planting 12 hours*0:37 P/h | 4:44 |
| No hand weeding 70 hours * 0:37 P/h | 25:90 |
| Total Income: | 30:34 |
| Costs: | |
| Planting 7 hours * 0:37 P/h | 2:59 |
| Mechanical weeding 1.5 pers* 10 h* 0:37 P/h | 5:55 |
| In row weeding 15 hours * 0:37 P/h | 5:55 |
| Planter[1] | 1:75 |
| Cultivator[2] | 0:41 |
| Total Costs: | 15:85 |
| Net profit per hectare | 14:49 |
| Return to labour per hour[3] | 0:76 |

(Notes see appendix 1 & 2)

The return to labour increases quite radically when rowplanting is combined with mechanical weeding. In dryland areas as well as in molapo areas it is mechanical weeding that gives the increase in return to labour, rowplanting will follow as a side effect. The labour made available allows a farmer to increase area planted with 0.8 hectares, to 3.4 hectares.

In Table 30 the labour requirements and return to labour is presented as if farmers had made the purchases of rowplanters and cultivators, this makes it comparable to Table 5.

Table 30. Resource Requirements in Proposed Arable Farming. Per Hectare.

| | Farmers using oxen | | Hoe farmers |
|---|---|---|---|
| Technology | rowplanter cultivator | | herbicides |
| Activity | Man hours | Oxen hours | Man hours |
| Ploughing | 18 | 24 | 10 |
| Planting | 7 | 14 | 15 |
| Weeding | 30 | 30 | - |
| Birdscaring | 35 | | 35 |
| Harvesting | 40 | | 40 |
| Total Hours | 130 | 68 | 100 |
| Income: | | | |
| Yield Pula | 65:00 | | 65:00 |
| Costs: | | | |
| Herbicide | | | 20:00 |
| Sprayer | | | 1:22 |
| Planter | 1:75 | | 1:75 |
| Cultivator | 0:41 | | |
| Total Cost | 2:16 | | 22:97 |
| Net profit/ha | 62:84 | | 42:03 |
| Return to labour P/hour | 0:48 | | 0:42 |

The result is that even with the use of herbicides, hoe farmers do not obtain the same return to labour as oxen farmers. On top of that they have considerable cash investments each year. Hoe farmers are generally the poorer households, wether they will afford considerable cash investments is doubtful.

# 6 Recommendations

The recommendations forwarded are all concerning the traditional farming systems. Irrigation has not been included in this report, but should not be forgotten as an important contributor to the development of the area. The recommendations are listed in order of priority, meaning that if the problem of soil erosion is not dealt with successfully there will be very little or no effect from intensified extension or improved crop protection.

## 6.1 Soil Conservation

This is most acute for the molapo soils in the Nokaneng Flats. The molapo soils are amongst the best soils found in Botswana, and they are blowing away into the Kalahari desert at an alarming speed. The ADN project have started a dialogue with local farmers about means of improving the situation, and the local communities are concerned over the environmental destruction that is going on. The means to protect the environment is however not with the local communities, and support from the Government is needed. The overall critical issue is to control livestock in order to prevent overgrazing.

## 6.2 Extension and Training of Farmers

There is no way to get around the fact that it is the farmers that are producing the food and it is they who will have to increase their production if there will ever be increased food production in Botswana. Farmers will never be able to develop their arable farming if the knowledge about improved methods and technologies never reach them. The extension service has to be improved both regarding organisation and more resources.

## 6.3 Land Tenure System

The land tenure system in the molapo areas should be studied, and if necessary changed. It seems that the traditional land tenure system is a major constraint to arable development in the molapo areas. Farmers must have secure control to land if they are going to invest in the land. Investments like fencing, fertilizers and weed control.

## 6.4 Crop Protection

For farmers to benefit from improved planting methods, improved seed varieties etc, they must have a strong relationship between plant population and yield. At present

molapo farmers have a very weak relationship. The cause for this weak relationship is the high level of risk farmers face. To reduce risk farmers must fence their fields and be able to control pests and crop diseases. Technologies already known in the control of pests and diseases should be disseminated to farmers. Agronomic and biologic control measures should be developed.

## 6.5 Storage Methods

It is essential that when farmers have managed to produce grain that they can store it with as little losses as possible. Storage techniques and losses should be studied. Adequate improved storage techniques should be identified.

## 6.6 Row Planting, Harrowing and Mechanical Weeding

The benefits from rowplanting are marginal unless rowplanting is combined with mechanical weeding. Mechanical weeding should be promoted by the extension service. Rowplanting should be credited for that it makes mechanical weeding feasible. Harrowing is necessary for successful row-planting and weeding in molapo fields.

## 6.7 Crops

Vegetables such as pumpkins and water mellons are during a great part of the cropping season a major food source for many farmers. These crops receive very little attention, and should be studied.

## 6.8 Hoe Farmers

Even if hoe farmers adopt the use of planters and herbicides, the later not being a recommendation, they will not obtain the same return to labour as farmers who are using animal draught power. A priority should be to encourage these farmers to make use of government assistance programmes in order to obtain draught power.

## 6.9 Terms of Trade Arable Farming

The arable sector is loosing labour to other activities that rural households are involved in. More and more households obtain a wider range of income generating opportunities. Often these activities offer higher returns to labour and higher security than arable farming. To ensure that labour will be available to arable farming, the returns from arable farming must be increased.

## 6.10 Arable Inputs

Arable Inputs should as far as possible be channelled through the private sector, and not as now by the extension service. To have staff with good training in agriculture handing out seeds and other inputs is a waste of much needed resources.

Notes to Table 20.

1. Labour valued to Pula 0:60 per hour according to table 7.
   Seed valued to twice BAMB Maun price for Maize.

2. 1.5 persons reflect one adult and one child. Gives labour for harrowing 12 hours/ha.

3. Price P 240:00 District Agriculture Office Gomare
   ALDEP grant 85% Farmer pays P 36:00

| | |
|---|---|
| Lifetime 10 years Depreciation | P 3:60/year |
| Interest 7% of P 36:00 | P 2:52/year |
| Total | P 6:12/year |
| Harrowing five hectares per year gives | P 1:22/ha |

4. Price P 300:00 DAO Gomare
   ALDEP grant 85% Farmers pays P 45:00

| | |
|---|---|
| Lifetime 8 years Depreciation | P 5:63/year |
| Interest 7% of P 45:00 | P 3:15/year |
| Total | P 8:78 |
| Planting five hectares per year gives | P 1:75/ha |

5. $$\text{Return to labour} = \frac{\text{Net profit+Labour costs}}{\text{Hours of labour}}$$

$$\text{Return to labour} = \frac{-9:77+7:20+6:30}{1.5 * 8+1.5 * 7} = \text{P } 0:17/\text{hour}$$

Notes to Table 21.

1. No increase in yield is calculated since the use of herbicides is compared to hand weeding. In practise many fields are unweeded or weeded to late.The use of herbicides is likely to improve timing and increase area weeded.

2. Even though trials were carried out with a low volume sprayer, the calculations are based on knapsack sprayer. In the molapo areas there is usually ample supply of water. Farmers are likely to buy a knapsack sprayer that is much cheaper than the tested low volume sprayer.

Price P 140:00 Price Gaborone

| | |
|---|---|
| Lifetime 5 years Depreciation | P 28:00/year |
| Interest 7% of P140:00 | P 9:80/year |
| Total | P 37:80/year |

Five hectares sprayed per year gives P 7:60/year

3. Return to labour = $\frac{29:40+3:00}{5}$ = P 6:48/ hour

Notes to table 22.

1 Price Cultivator estimated P 70:00
According to Molapo project the price might be as low as P 60:00 in Maun.

ALDEP grant 85% Farmer pays P 10:50

| | |
|---|---|
| Lifetime 8 years Depreciation | P 1:31/year |
| Interest 7% of P 10:50 | P 0:74/year |
| Total | P 2:05/year |

Weeding five hectares per year gives P 0:41/ha

2. Return to labour = $\frac{26:32+7:20+6:30+9:00}{52.5}$ = P 1:10/hour

Notes to table 25.

1. Labour valued to Pula 0:37 per hour according to table 5.

2. Herbicides The cost for herbicide is estimate since no fixed recommendation can be given.

3. Sprayer Price estimated to same as producer price England, local manufacture is assumed, as is ALDEP subsidy.

   Price Pula 300:00

ALDEP grant 85% Farmer pays P 45:00

| | |
|---|---|
| Lifetime 5 years Depreciation | P 9:00/year |
| Interest 7% of P 45:00 | P 3:15/year |
| Total | P 12:15/year |

Spraying 10 hectares per year gives P 1:22/ha

4. Return to labour = $\frac{11:28+2:50}{10}$ = P 1:38/hour

Notes to table 26.

1. Labour valued to Pula 0:37 per hour according to table 5.

2. See Appendix 1.

3. Return to labour = $\frac{0:10+2:59}{7}$ = P 0:38/hour

Notes to table 27.

1. Price assumed local production and ALDEP subsidy. Pula 300:00

   ALDEP grant 85% farmer pays P 45:00

| | |
|---|---|
| Lifetime 8 years Depreciation | P 5:62/year |
| Interest 7% of P 45:00 | P 3:15/year |
| Total | P 8:77/year |

Planting five hectares per year gives P 1:75/ha

2. Return to labour = $\frac{1:13+3:60}{15}$ = P 0:32/hour

Appendix 3.

Linnear regression:

Konstant of X= 1020 kg/ha s.e.= 1670 kg/ha

X Coefficient = 0.021 s.e.= 0.007

R= 0.245 $R^2$= 0.060

n= 128 degrees of freedom= 126

Gives the line Y= 0.021X+1020

where Y= yield in kg/ha

X= plants in thousand/ha

Significant at the 1% level

Six percent of variation in yield is explained by variation in plantpopulation.

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