Addressing Constraints to Agricultural Production in Lerala

Interdisciplinary Land Use and Natural Resource Management

By

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ABBREVIATION AND ACRONYMS

AD	-	Agricultural Demonstrator
AF	-	Artificial Fertilizer
ALDEP	-	Arable Land Development Programme
ARAP	-	Accelerated Rainfed Arable Programme
BAMB	-	Bostwana Agricultural Marketing Board
BWP	-	Botswana Pula
CEDA	-	Citizen Entrepreneurial Development Agency
CM	-	Chicken Manure
CSF	-	Case Study Farmers
FAO	-	Food and Agriculture Organization
FAP	-	Financial Agricultural Programme
FHHH	-	Farmer Headed Household
GDP	-	Gross Domestic Product
GoB	-	Government of Botswana
HH	-	Head of the Household
KM	-	Kraal Manure
KYT	-	Kgeitse Ya Tsie
MoA	-	Ministry of Agriculture
MHHH	-	Male Headed Household
NAMPAD	-	National Master Plan for Agricultural Development
PRA	-	Participatory Rural Appraisal
SOM	-	Soil Organic Matter
SPSS	-	Statistical Programme for Social Science

PREFACE

The report addresses the constraints to arable agricultural production in Lerala. The research objectives are investigated through an interdisciplinary approach.

Subsistence farming is generally practice in Lerala. Unreliable rainfall associated with poor soil fertility and pests was found to be the major ecological constraints hindering agricultural production. The social issues involving, labour, motivation for farming of the youths and production inequality between genders are constraining subsistence farming sustainability. Access to capital and availability of local market are economic constraints that farmers are facing. Government programmes do not address the need to improve the livelihood of the subsistence farmers. However potential solutions to meet the constraints will be suggested in recommendation section.

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1. INTRODUCTION

1.1 National importance of agriculture

Since Botswana's independence in 1966 the agricultural sectors contribution to the national gross domestic product has fallen from 40% to 3.1 % of GDP (Ministry of Agriculture, MoA 2005, NAMPAD 2000). This decline has often been attributed to the rapid increase in the contribution of minerals like diamonds. Despite the fact that due to the environment, less than 5% of the land of Botswana is cultivable, agriculture remains an important source of food, income and employment for the majority of the rural households. Furthermore, the poor performance of the sector has a negative influence on the national economy in the sense that it has contributed to Botswana's dependence on imports to secure basic cereals. In the middle of the 1980's the political awareness of the low productivity levels of the agricultural sector led to the implementation of agricultural programs in form of the ARAP (Accelerated Rain fed Arable Programme) and the ALDEP (Arable Lands Development Program). These programs were attempts to meet the objectives of food security at both the household and the national levels. However, in spite of these initiatives, low and declining productivity of the sector continues (Seleka, 1999). Since 2002 the MoA has prepared a National Master Plan for Agricultural development (NAMPAAD) to improve agricultural performance and making it competitive and able to reduce Botswana's reliance on import.

Table 1: Production yields in Botswana in selected years from the period 1979-2002

Yield (kg/ha)	Sorghum	Maize	Millet	Groundnuts	Pulses
1983	40	148	29	800	14
1986	86	82	74	129	33
1988	338	141	225	282	128
1990	185	147	135	257	98
1995	685	220	1708	85	394
1997	67	189	129	193	58
1999	47	30	109	73	36

Source: Gopolang, 2004

Looking at yield values for the national production, there is great variation over the years. Table 1 represents a few years with high differences selected from a period of 23 years between 1979 and 2002. Comparing table 1 with figure 1 below shows clear correlations between rainfall and yields. The years of drought have very low yields. This variability makes farming a risky business for the farmers in Botswana.

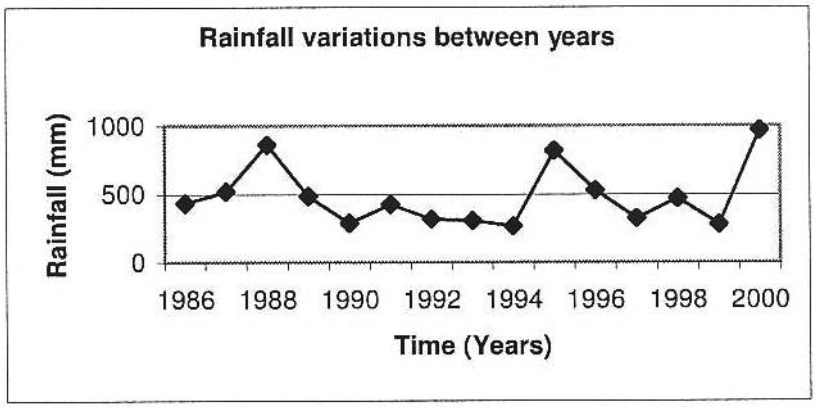


Figure 1: Rainfall variation over the years. (Source: Department of Metrological Service Botswana)

1.2 Regional Production

Lerala is situated in the central district where the annual precipitation is between 350 – 500mm (Atlhopheng et al, 1998). Figure 2 illustrates the rainfall for Lerala from March 2004 to January 2005. The central district is one of the best agricultural zones of Botswana; however the unreliable and limited rainfall poses a serious hindrance for cultivation of many crops. The regional production of the central district is focused very much on sorghum; the 2002 statistics show that the area planted with sorghum was 1.2 times larger than for maize however the area harvested was 3.2 times larger (Gopolang, 2004). This shows that much maize planted was not harvested creating a larger dependence on the sorghum harvest.

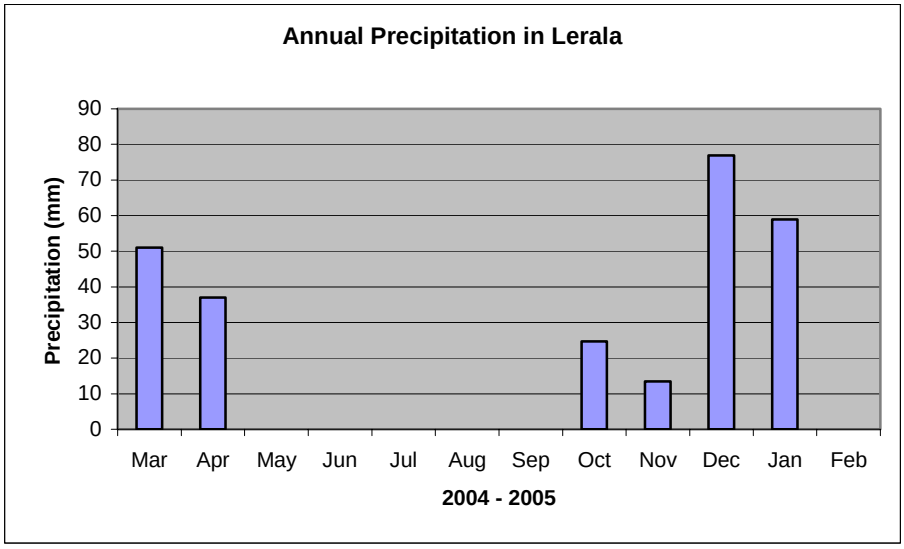


Figure 2: Annual Precipitation in Lerala from March 2004 till January 2005.

1.3. Lerala

1.3.1 Production

The commonly grown crops in Lerala are sorghum, watermelons, black-eyed beans (cow-pea), groundnuts (bambara and peanuts), maize, millet and sweet reed (sugar cane). Sorghum is grown on the largest area and is considered the staple food crop, as it is drought resistant. However melon is even more drought tolerant and is intercropped with sorghum to secure harvest in years of drought. Beans are also an important crop because the green leaves are harvested as well as the bean pods during the entire growing season. Leaves are dried and used for food consumption. Groundnuts are a significant cash crop, however connected with a labour intensive post-harvest treatment. Maize is by farmers recognized as a rain requiring crop, hence only grown in wet years. Millet and sweet reed was grown to a smaller extend. Average yields of some of these crops are: 50kg/ha for sorghum and millet, 25kg/ha beans and 500kg/ha melons (Masutlhe). The yields are lower than the regional production value. This fact together with the few active farmers in Lerala leads us to believe that Lerala is not self-sufficient in food production. Consequently, high importance on increasing food production in order to improve food security and decrease dependence on food aid from outside should be placed. Additionally, if yields increase livelihoods are likely to improve due to harvest used in bartering or as alternative source of income.

1.3.2 Farming Practice

The agricultural year is simple in the sense of soil treatment. At the onset of rain, usually in November or December, the mixed seeds are broadcasted, followed by a tractor or a donkey with a small plough. Men usually perform this practice if they are part of the household if not women also plough. In the next 4-6 months depending on crop variety and species the fields are hand weeded, which is mostly undertaken by women. After all crops are harvested (around June) livestock graze the fields until October. This is undertaken by the activities a majority of the subsistence farmers however, there are additional activities related to agriculture, which are described in the seasonal calendar in Appendix A. Eight male farmers have adopted the advice from the agricultural demonstrator and started the new practice of row planting. In these cases the soil is ploughed, then harrowed in order to level the seedbed and finally a planter sets the seeds. These cultivations can only take place at adequate soil moisture.

1.5. Research objective

In the light of this context the objective of this report is to assess the importance of agriculture for local livelihood in Lerala and to analyse the major ecological and socio-economic constraints to arable agricultural production. We are going to address this objective by analysing the agro-ecological conditions, focussing on soil nutrient status, water conservation management, pests and diseases. This investigation will also address issues such as soil amendments/fertilizer use (organic and artificial) and cropping systems/practices. The second step is to analyse the socio-economic conditions necessary for maintaining crop production over time. This includes analysing the labour availability and distribution, farmers' access to market, credit institutions and land. We will in addition focus on gender bias and less affluent farmers' situation in agriculture.

Throughout the report the following is going to be our objective and research questions:

What are the main constraints to arable agricultural production in Lerala and how do the farmers cope with these constraints?

1.5.1 Research questions

1. What is the nutrient status of the soil and are there risks of nutrient deficiencies?
2. What kinds of water conservation management strategies are practiced and how do they affect crop production?
3. What are the main agricultural pests, how severe is the impact thereof and what measures can be made to decrease the impact?
4. How are the agricultural practices in terms of cropping systems, choice of crops and rotation influencing the agricultural production?
5. How does the farmers' access to capital, credits and market influence agricultural production?
6. What is the availability of labour for agriculture?
7. How does agricultural production relate to gender, wealth and education?
8. Is access to land a constraint to agricultural production?
9. How is the government responding to agricultural constraints?

1.6 Limitations

In order to strengthen the focus of the report we are concentrating upon issues directly related to agricultural production. The fact that 33% of the working population has HIV/AIDS imposes severe constraints on agricultural labour availability. However given the limitations of this report we will not directly investigate the affect of HIV/AIDS. Post-harvest techniques will not be included either and the PRA nutrient flow chart was not made due to insufficient knowledge of application amounts.

2. METHODS

We address the complexity of our subject by using an interdisciplinary approach, combining natural science and social science research methods. Through this interdisciplinary approach we are going to focus on the inter-linkages between the different aspects of agricultural production in Lerala. The sections below are the main methods we used which reflect our experience, advantages, disadvantage and shortcomings in the field.

2.1. Questionnaire: advantages/shortcomings

The questionnaire is used primarily to get fast quantitative data in the field. We used a common questionnaire incorporating each assigned subjects for the purpose of saving time and to cover more households. We used a combination of stratified and random convenience sample technique (Babbie 2002). Furthermore, the common questionnaire supports the interdisciplinary approach in terms of benefiting from common knowledge and inter-linkages between the subjects. On the other hand some questions were not directly relevant to our group and we also had to drop some question which could have been relevant to our study, because of the compromise involved in doing a common questionnaire.

2.2. Case study farmers: selection criteria advantages/shortcomings

We chose to use CSF in order to get precise in depth qualitative knowledge from the local farmers. In the synopsis, we planned to select case study farmers (CSF) according to their economic status. This was not realized because we found out that it is very complex to measure the wealth of an individual household. Therefore we changed the criteria to farmers' agricultural practices and chose our CSF according to gender and by convenience through referral from the questionnaire. However, the ones who ploughed this year and from who we therefore could get information on the agricultural practises often turned out to be relatively well-off, thus not representative of the average farmer in Lerala. Therefore it was necessary to broaden our selection of informants to less well-off subsistence farmers. Through that process we learned that sometimes the affluent informants were less willing to be interviewed and had less information to provide. The reliability of the information from these CSFs and our less in depth information from affluent farmers are the disadvantages of having CSFs. Alternatively, we could have chosen an affluent farmer as a CSF but that farmer would most likely not have ploughed this year. The choice of case studies is a central

element of this report because it contributes to the practical empirical knowledge of the concrete agricultural practises in the context. The strength of the CSFs is that the analysis of the particular farming practises in their own context allows a sense of reality, which can contribute to the understanding of the phenomena, which we are investigating (Flyvbjerg 1991). Nonetheless, it can be difficult to generalise on the basis of the CSFs, and we are aware of the fact that working in debt, to a certain extend, is at the expense of the width.

2.3. PRA: advantages/shortcomings

We used PRA methods of problem ranking, seasonal calendar, opportunity ranking, Venn diagram and matrix ranking. Together with our counter parts, we decided to separate the genders to get their different perspectives. This way the stakeholders could express themselves more freely because the presence of the other sex can influence on the response especially in a male biased context (Mikkelsen 1995). These methods provide a general overview and basic understanding of the agricultural practices, problems the farmers encounter and social issues that are good leads for discussion. The PRAs were the most challenging methods because it involves groups of people participating with different ideas, characters and levels of understanding. Due to little experienced with this method we few times interrupted the exercise, which is against the idea of PRA. We also needed more time to discuss with our counterparts on how to do the exercise in the actual setting because they know more about the culture and behaviour of the people in the area. Furthermore, working with translations can be a disadvantage since the translators are not familiar with the methods. Some of the concepts might not be directly translatable to the local language. Therefore it took time to understand and explain the exercises and to give the answers back to the facilitator, which influenced the results of the exercises.

2.4. Soil analysis: advantages/shortcomings

The soil analysis was performed partially in Botswana and partially in Denmark. The soil samples were taken from the case study farmers, of which we picked 4 within the following criteria: No input, organic manure input, artificial fertilizer as input and a fallow field. The sampling technique used was to take 3 sub-samples in a zigzag pattern of 20 cm depth and mix them together to make 1 sample. This was done for all CSFs, however the kraal samples represents only 1 drilling. On these soil samples we performed field tests and laboratory tests. The field tests consisted of conductivity, pH, potassium content and phosphate content, by estimating the content through colour change. In

the University of Botswana we made additional pH, phosphate and potassium content measurements. It was easy to distinguish between high and low contents however the exact amounts were still unknown. Therefore we performed the analysis again. In Denmark we made an elementary analysis on the samples and obtained total nitrogen and carbon contents. Phosphate measurements were made again on a spectrofotometric Hitachi u-2000 machine, which gave us exact values. We also performed an infiltration to identify the potential of the soil in relation to soil conservation technique; however we should have performed it on a field with plant residue as soil moisture conservation technique. We conducted a gravimetric method measurement for soil moisture content; however it didn't work due to lack of equipment. There is a clear advantage in obtaining some indicative results in the field on the nutrient status of the soil though it takes a lot of coordination to keep chemicals and samples treated correctly when many group-members are helping to do the tests. The chances of mistakes are greatly increased which jeopardize the results.

2.5. Interviews: advantages/shortcomings

We did 20 qualitative semi-structure interviews with our case study farmers, key informants, focus group-interviews with the youth, follow-ups and a couple of snow balling non-structured interviews (Babbie 2002) (See appendix B for interview guides and appendix list of informants). We found it easy to use this method since the people in the village were generally very cooperative but it takes time to formulate relevant follow-up questions during the interview process. Often we had to ask side questions, just to keep the conversation going. The translation plays an important part in the interview process. It was observed that sometimes when we asked a short question the translation was very long. Likewise, if the farmers gave long answers the translations were short which made us feel unsatisfied and wondering if the information was reliable. We should have briefed our translators more before going to the field because we rely heavily on the information gained through using semi-structured interviews.

3. CONSTRAINTS FOUND IN THE FIELD

3.0 Introduction

This section starts out with a description of the case study farmers found in the local setting. The CSF will be referred to throughout the report when illustration the constraints. Then it takes its point of departure in the ranking and goes on to discussing our results on the constraints found in the field with the objective of answering the research questions.

3.0.1 Local Setting

3.0.1.1 Case study farmer #1

CSF 1 is not the primary decision maker related to the farmland; this was her mother (HH: head of the household). However HH was not available at any time, hence CSF 1 was chosen as key informant also because she was very eager to talk to us and had substantial knowledge about her mothers land. HH owns a total of 20ha however since her husband died 34 years ago she has only been cultivating about 1 ha currently planted with sorghum, sweet reed, maize or groundnut intercropped with melon. HH represents the traditional farmer, however slightly above the average income level. HH was able to take the risk of sowing in December despite the lack of rain. HH did not use any fertilizers or pesticides but rented a tractor to plough after broadcasting. This was done primarily because neither HH nor CSF 1 were comfortable using animals as draft power.

3.0.1.2 Case Study Farmer #2

CSF 2 is the owner of a local butchery and owns one of the largest general dealer shops in town. He has 18 ha in one big field where he crops all the commonly grown crops in Lerala, sweet potato and other vegetables. Additionally the informant has a borehole in the field, where the water use is limited to vegetables. The informant wants to intensify his vegetable production, as he is aware that the currently agricultural support program (NAMPAD) focuses on horticultural productions and because horticultural crops have a higher return profit than cereals. CSF 2 has mechanical implements and a tractor, however still chooses to broadcast melons seeds within the row-planted cereals. CSF 2 also has a chicken farm in Lerala from which he transports chicken manure to the field. In December 2003 he applied the manure to ¾ of his plots.

3.0.1.3 Case Study Farmer # 3

The third CSF was our interpreter, who was chosen because her fields were fallow and had been for quite some time. CSF 3 is a young woman of 25, who cultivates when she has money for renting a tractor. Primarily she relies on family members to sustain her livelihood in form of food and clothes as both her parents are dead. In the analysis of the fallow field soil samples it must be kept in mind that these fields had been cultivated around 4-5 times within the last 10 years (not sequentially), hence it is not a permanent fallow being analysed. Furthermore, in terms of being a young single woman she was interesting in relation to the socio-economic aspects of the analysis.

3.0.1.4 Case Study Farmer #4

CSF 4 is of special interest to the soil analysis as he has applied artificial fertilizer to some of his fields. The informant is a former member of the Farmers Committee (as well as CSF 2 is) and has partially adopted the row planting technique. Additional the informant can be viewed as an entrepreneur based on the history of his previous agricultural productions and experience with pigs and orange trees. Currently CSF 4 is looking into applying for funds and permission to install a large reservoir to store water from his two boreholes in order to irrigate up to 5 ha per season. As in the case for CSF 2 the irrigated plots will be primarily be grown with vegetables. He is also interested in applying for NAMPAD, however does not know anybody to do it with.

3.1 The Ranking

Two groups of locals were asked to make a ranking of the constraints to their agricultural production. First a group of male farmers and then a group of female farmers were asked to discover differences in the constraining factors between the sexes. The results were as follows:

Male Farmers	Female Farmers
1. Unreliable Rainfall 2. Draft power 3. Farm equipment/ implements 4. Hard work 5. Pests (birds, worms, crickets, roaming livestock) 6. Low soil fertility 7. Seed availability 8. Labour	1. Unreliable Rainfall 2. Draft power 3. Pests (birds, worms, locusts, roaming livestock) 4. Weeds (Molelwana & kgonkguroso) 5. Implements (e.g. planter) 6. Labour

**The points 2-6 were also mentioned in relation to the need for money to solve these constraints.*

The constraints mentioned between the two groups will be discussed in the following section however not in the given order.

3.2 Water

It was expected that the unreliable rainwater would impose severe limitations on the agricultural production. Unreliable rainfall is a very difficult constraint to overcome. However, there are few technical options to meet this constraint. The most obvious choice would be establishing irrigation. Other practical options include applying mulch and adjusting tillage and cropping systems especially planting time and density. Using mulch does not seem realistic because vegetation is extremely sparse and when available used as animal fodder. Research has shown that the effectiveness of soil cover decreasing soil water evaporation in tropical climates is questionable due to the intense heat (Raunsø-Jensen, 2004). The other technical options are however controllable by the farmers and the result and analysis found on these will be given below.

3.1.1 Irrigation

Using irrigation is not the easiest choice for most farmers primarily due to limited capital and lack of access to boreholes. Secondarily, underground water reservoirs vary greatly with groundwater

level varying between 40-70 meters below the surface. This could mean that the water supply for crops through a growing season can be restricted. CSF 2 and 4, who have boreholes are advised not to irrigate more than 1 ha per borehole. Making irrigating cost-effective high value crops are grown on the irrigated areas. When applying for a loan for boreholes and irrigation systems a sum of 60000 BWP are given. Considering this sum of money and the production, which can be gained from irrigation it is not cost-beneficial. Additionally, farmers' lack of knowledge on utilizing irrigation schemes constraints potential benefits. Consequently, if subsistence farmers are going to obtain access to irrigation the state must finance these large-scale investments. However, this raises questions about the environmental sustainability of such a project, in terms of water scarcity and prioritisation thereof in a semi-arid environment. May (1998) removes this apprehension towards irrigation with statements about unlimited availability of groundwater resources. Hence, the environmental sustainability of potential irrigation needs more investigation.

The average infiltration rates measured on the fields of CSF 1, 2 and 3 are depicted in Table 2. Traditional field (CSF 1), which was ploughed for 30 years straight, has a high infiltration rate of 21.0 mm/min, where it is 2.6 mm/min for irrigated field (CSF 2) and 11.0mm/min for the fallow field (CSF 3). Soils with high infiltration rate absorb water fast into the root zone thus making it easy for the plant to utilize the water. It also minimized the runoff and evaporation from the field.

The differences in soil types consequently influence the infiltration rate. The soils are mostly sandy loam in the village therefore fairly high infiltration rates should be expected. This is reflected in the result from the traditional field. The irrigated field had the lowest infiltration rate due to it being water saturated when sampling was made. This fact could indicate oversupply irrigation.

Table 2. The infiltration test was taken on these fields from the CSFs

(mm/min)	Traditional Field	Irrigated Plot	Fallow Field
Infiltration Rate	21.0	2.6	11.0

3.1.2 Soil Moisture Conservation and Tillage Method

When asking about soil moisture conservation methods being practiced the AD and the secretary of the farmers committee gave the example of winter ploughing and row planting. The term winter ploughing refers to turning the soil between harvest and the onset of rain in the winter months of

June, July or August. This would break the plough pan, decrease run-off and in theory increase water infiltration rate and the soil water content.

Comparison of the infiltration rates between a winter-ploughed and not winter-ploughed field was not made. This could have provided an indication of whether winter ploughing increases potential water uptake. Yields from winter ploughed and not winter ploughed fields under the same conditions (soil types and inputs) could also have given an indicator of the effectiveness of this practice, however again this was not accessible.

3.1.3 Cropping Systems

When row-planting a more equal seed distribution is achieved compared to broadcasting seeds. The distribution provides less intra-specific competition between crop plants and together with the fact that seeds are placed in favourable sowing depth improves germination. Hence planting density differs between the two systems. As mentioned earlier when row planting the soil is turned several times more than when broadcasting seeds. This results in looser soil structure but also a delay of sowing time, making germination delayed but more secure. Broadcasted plants can utilize more rainwater than the row-planted plants. Broadcasting is also an attractive method as it is not as labour intensive as row planting, which is important in a society where the elders primarily undertake farming. However, it is not always so that the broadcasting farmers can solely decide when to sow as this is highly related to tractor availability. There are only 3 tractors available for rent in Lerala, which results in long waiting list. Additionally, personal relations tend to influence the order of this waiting list (Cornelius). The price for renting a tractor is 180BWP.

It is not possible to make a comparison between the yields from a broadcasted field and a row planted field because the row planted fields were fertilized. However where agriculture has been intensified through planting in rows in other parts of the world yields have improved significantly. However within the social and environmental context of Lerala, it is not sure that planting in rows would secure higher yields.

Farmers rarely follow the row planting advice because first of all it requires technical equipment and knowledge. Investing in a row planter does not necessarily increase production in a bad year, since environmental constraints might hinder prospect of a good harvest. The fact that only one AD

aids around 500 active farmers creates the need for additional government extension workers to provide service and education about new techniques, which is essential if these are to be adopted by farmers. Farmers are interested in labour reducing farming methods but sometimes farmers do not comprehend the full benefits of row planting. Seeds being broadcasted within the rows indicate this. A second reason for not adopting row planting is the risk adverseness of the subsistence farmers. In theory the farmer would have to allow the possibility of total crops failure when row planting because it would be mono-cropped hence the food security achieved from intercropping disappears. The farmer must also be able to utilize the benefits of a row-planted crop e.g. mechanised weeding, fertilizing and pesticide application if needed. If the farmer doesn't have sufficient capital and labour to insure these benefits planting in rows is not feasible.

By interviewing less well-off farmers we found that rich farmers and poor farmers are not equally motivated, skilled or informed when it comes to adopting new agricultural methods. This was reflected in the CSFs' different attitudes towards risk taking and the fact that only 8 male farmers have adopted row planting. Farmers rarely cling to ancient methods simply due to desire to maintain customs and traditions. Rather change is often slow due to many small-scale farmers being very poor, often makes them extremely risk-averse (poor farmer interview). Row planting could increase production but if not successful bring the family income from near subsistence to below subsistence. This devastating consequence may simply outweigh the potential gains. Many small-scale farmers remain caught up in traditional production techniques, not out of choice, but because they have little or no access to cash or credit, which would enable them to finance advanced technologies.

3.2 Soil fertility

Male farmers ranked lack of fertilizer as number 6. This supports low soil fertility as a potential constraint. The impact of this constraint will be discussed through the results obtained partially through the interviews and through testing of the soil sample taken from the CSFs. First the agricultural inputs used in Lerala will be discussed and their socio-economic relevance, secondly the soil analysis will be made differentiating between the CSFs and the kind of input used. Finally, yields will give an indication of how soil fertility constrains agricultural production.

3.2.1 Inputs

Agriculture in Lerala can be characterized as low-input extensive, where most farmers use no inputs in terms of fertilizers (organic or artificial) and pesticides. However, two of the CSFs, which were also the ones that adopted the row planting techniques, use artificial fertilizer and goat manure (CSF 4) and chicken manure (CSF 2). Informants expressed concerns about kraal manure being too acidic for the soil, creating further acidification and decreasing soil fertility. The locations of the kraals on the grazing lands make the transport a labour intensive process, which would not be pursued unless positive results are secure. Farmers have easy access to organic manure if they possess livestock, which is seen in CSF 2. Most farmers without livestock or means of transportation have difficulties obtaining this access. However, when livestock is possessed, it is hard to differentiate whether it is the general perception about kraal manure not being useful, or the transportation difficulties that is the main hindrance.

3.2.2 Soil sample analysis

The soil samples were grouped into 6 categories with the following names:

1. **Traditional**; 6 soil samples from the fields of CSF 1
2. **Chicken Manure** (CM); 2 soil samples from the fields of CSF 2, where some of it had been applied with CM
3. **Irrigated**; 1 soil sample from a 1 ha plot on the fields of CSF 2, which was also applied with CM
4. **Fallow**; 3 soil samples from the fields of CSF 3
5. **Artificial Fertilizer** (AF); 3 soil samples from the fields of CSF 4, however we do not know exactly what fields were fertilized.
6. **Kraal Manure** (KM); 1 sample taken of soil within a kraal on the field of CSF 4.

3.2.2.1. PH Analysis

The analysis, which is shown in table 3, gave a pH range between 6.3 and 7.5. This implies no immediate threat of acidification on the fields. The fallow field has the highest pH besides the Kraal soil hence applying KM should not lower pH. The traditional cultivated field has the lowest pH, which could indicate that sequentially cultivating the same plot year after year lowers pH. Most of the informants encountered in the field had many hectares of land but cultivated only a few of them. However, the rotation of the cultivated plot (AF) on the fields of CSF 4 resulted in higher pH than

the traditional plot where the same plot was cultivated for the past 30 year. Any micronutrient deficiencies possible existing cannot be corrected by liming the soil, since most of these happen at pH below 6. We can also conclude that there are no risks of Aluminium toxicity.

Table 3: The pH values of the 6 categories

	Traditional	CM	Irrigated	Fallow	AF	KM
pH	6.3	7	7	7.2	6.5	7.5

3.2.2.2. Phosphor Analysis

Analysis of Olson extractable phosphate content shows very low results (figure 3). The traditional field is the most P exhausted and is in need of phosphorous fertilizer. Field observations revealed crops in poor conditions; however it is not to know whether it is rainfall or lack of nutrient that is the limiting factor.

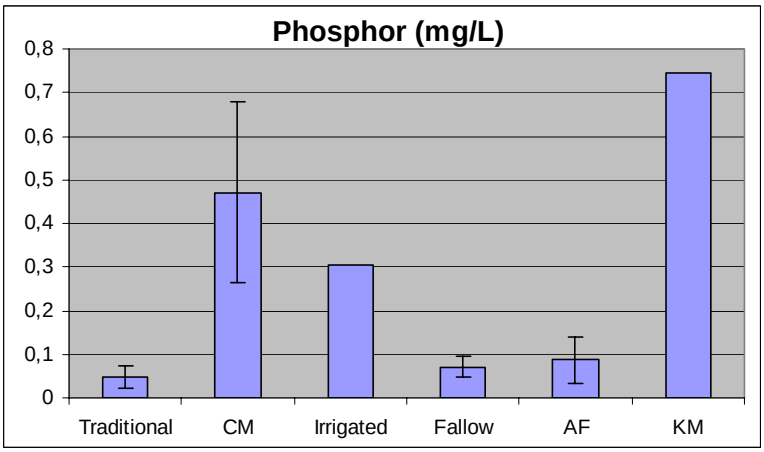


Figure 3: Phosphor contents of the soil samples. The results are showed with standard deviations. The different categories had the following number of samples within: Traditional: 5 (6 samples were taken but 1 was excluded to due laboratory default), CM: 2, Irrigated: 1, Fallow: 3, AF: 6, KM: 1.

The fallow field indicates that letting the fields rest doesn't deplete the soil as fast as sequentially cropping however applying fertilizer makes a difference. AF has not significantly higher P content than the fallow field indicating that the amount of AF applied to the field was insufficient to increase the content reasonably. It is not surprising since, taking the costs of fertilizer into consideration, the size and amounts of applications are very small. CSF 4 reasoned that:

"It is only necessary to apply AF every third year or so because it takes a long time for it to work in the soil".

However, this is not the case as AF dissolves fast in the soil, when soil water content is high enough. There might even be a risk of leaching due to the time of application. The amount that CSF 4 applied was ¾ of a 50kg bag of 2-3-2 NPK fertilizer (25% active dose), spread on 2 ha of sorghum. This equals around 2kgP/ha a value extremely low comparing to the AD's recommendations, which was 200kg of fertilizer per ha. Calculating this into kg P/ha gives 21kgP/ha. The fertilization does not meet the crop requirement. CM and irrigated fields have fairly high P contents therefore the application of CM was sufficient. CSF 2 owning a chicken farm has access to CM. Additionally, the soil from the kraal has a high content of P suggesting benefits from utilizing kraal manure to increase soil phosphate.

3.2.2.3 Potassium analysis

The soil tests of potassium (K) gave results in form of high, medium and low content. Table 4 illustrates the findings, with ( ) denoting the number of samples identified within the result criteria. The amount of samples tested from each category is the same as mentioned below fig.3.

Table 4. The result using the Tai-kit when testing for potassium

Traditional	Irrigated	CM	Fallow	AF	KM
Med (1) Low (5)	Low (1)	Med (1) Low (1)	High (2) Low (1)	Low (6)	High (1)

Generally, the fields are very low in potassium; however when measuring relative values we do not know if this is the crop-limiting factor. The fallow fields and the KM have the highest contents of K, indicating an advantage for increasing the soil content of K by fallow or applying KM. The AF fields did not show increased K hence the amount supplied is insufficient.

3.2.2.4. Organic Matter Content (Total N and C)

In this section the irrigated field has been grouped under CM as these results were similar. This can be justified as the decomposition of SOM is a very slow process and the plot had only been irrigated for about one year. Total N and C contents will be presented on the figures 4 and 5 below to

illustrate the differences between the 4 different types of cultivation and especially the soil from the kraal.

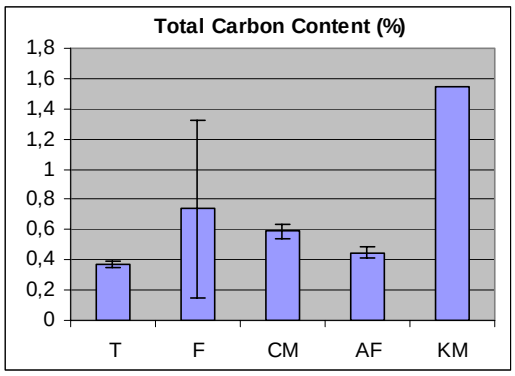


Fig. 4 Total C soil content in percentage

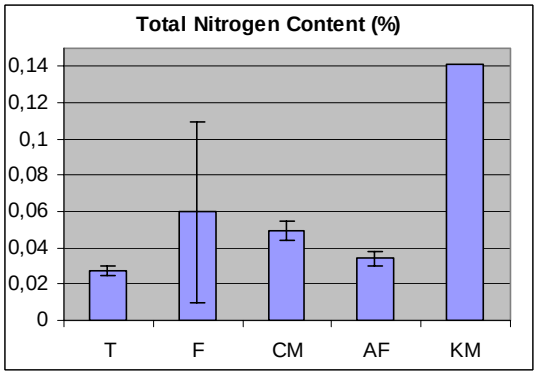


Fig. 5 Total N soil content in percentage

(The number of samples is the same as for the phosphate analysis except for the inclusion of all 6 samples from the traditional category)

The KM soil is high in both C and N, which support fertility benefits of using kraal manure. The standard deviations are fairly low except for the fallow field. The field with CM have higher C and N contents than the AF fields, due to the application of organic material within the CM. CSF 4 (AF sample) also applied a little goat kraal manure, which could justify the higher carbon content compared to the traditionally cultivated field that never received anything. This difference is however minor. A final comment states that fertilizing the fields with CM does slightly increase the nutrients of C and N and that farmers that don't use fertiliser cannot maintain the P content hence applying fertilizer is necessary.

3.2.3 Production relating to soil fertility

A comparison between the harvests of the CSFs is illustrated in table 5. The comparison is made for the sorghum since these were the only plots fertilized with AF by CSF 4. CSF 2 obtained the highest yield from 2004. When looking at last year's production the CM fields harvested far more (610 kg/ha) than the AF fields. The latter only produced 230 kg/ha more than the non-fertilized field.

Table 5: Yields from last year and a good year. Data received through interviews.

(2004/wet year)	Traditional	Chicken Manure	Artificial Fertilizer
Sorghum Yield (kg/ha)	960	1800/7200	1190/4025

CSF 4 doesn't achieve the full benefits of using AF since his yields are only slightly higher than CSF 1s. Considering the cost of AF it's more profitable to either apply more or pursue organic manure at less cost. The cost of applying organic manure is determined by ownership and location of livestock. This indicates a relationship between soil fertility, productivity and owning cattle. The fields applied with the CM had the highest nutrient contents of K, P, N and C illustrating the necessity of applying organic fertilizer. The results from the KM sample also shows soil fertility benefits from manure application Finally, the soils have very low contents of the nutrients measured (P, K, N and C) and even in rainy years poor soil fertility could be a constraint to crop production.

3.3 Pests

Female farmers ranked pests as third most constraining factor to agricultural production, males ranked it as number 5. Regardless of the ranking there were for both groups many categories of pests. A more detailed ranking by women showed birds, locusts and worms to be more constraining than weeds and roaming livestock on the fields as least constraining. Both birds and roaming livestock impose detrimental consequences on harvest. Roaming livestock is however not a problem for farmers that have been provided fence for arable fields by the government. Against the birds farmers don't have efficient pest removal; this is something that could be provided by the government as seen in South Africa.

3.3.2 Migration & non-migration species

The most prevailing pest problems where by the AD distinguished into two groups according to whether or not the government is meant to take action against them. These are grouped into migration and non-migration species. The first group is pests like birds, rats, grasshoppers, ants and locusts that only have manual treatments. The CSFs have different problems for instance the CSF 1 claims worms on cereals as severe, which was not a problem for CSF 4 who had sprayed for this once a few years back and was more concerned with red flies that eat the watermelon flowers. The most pressing pest among the migration species appears to be the locust and grasshoppers. But CSF 4 states the burden is lessened if the fields are surrounded with fallow boundaries, which attract the grasshoppers more than the crops.

The non-migration species which occur in outbreaks are sprayed by the government. These are corn cricket, African bore worm, grain beetle, fruit fly and stem borers. The most pressing pest problems for the farmers represent a mixture of the ecological conditions of the fields as well as the farmers' economic means to fight the pests. This statement is generally true for the means farmers have to increase agricultural productivity.

3.3.4 Weeds

Both CSF 1 and CSF 2 identified weeds in the field with great concern. One of them was collected and identified by a local woman as Mokhure setlheitsheina (Setswana name), which is of the *Datura* species being either *D. ferox* (Large thorn apple) or *D. stramonium* (Common thorn apple) (Henderson, 2001). Farmers explained it has a poisonous affect on crops, but different opinions existed on whether it was all crops or only sorghum and whether it would limit the growth or kill surrounding crops. Additionally *Datura* spreads vegetatively hence fighting it manually is a job like Sisyphus's.

Weeding is a very strenuous task undertaken by all farmers, mostly women, which is reflected in the ranking where only the women mentioned it as a constraint. Few farmers are in a position to hire labour for weeding which costs 20 BWP/day/person. It takes about 2 weeks for 6 people to weed 3 ha of sorghum, adding up a cost of 1680 BWP. These 3 hectares can be mechanically weeded by tractor in a day. The benefits of planting in rows in terms of saved labour are enormous; however the benefits disappear when melon seeds are broadcasted in between the row of sorghum as done by CSF 2. However in case of a dry year CSF 2 will benefit from a yield of melons also. In the light of the labour spend on weeding it is clear that the presence of weeds impose a constraint on the crop production, which in this environment could be relieved by row-planting and spraying pesticides.

3.4 Capital

The problem ranking shows that besides erratic rainfall, the problems ranked 2-6 by female and ranked 2-8 by male are problems related to the availability of capital for investments in agriculture. Capital availability is especially a constraint for the subsistence farmers. To assess the costs of agriculture we made a cost benefit analysis of the primary fixed and variable costs in small-scale farming based on the information we gathered from our CSFs.

Figure 6:. Cost Benefit Analysis of 1 Ha Planted with Sorghum

Average Commercial Farmers With Vehicles	Subsistence Farmer Rain fed
Cost • Fuel for Tractor 75 • Fertilizer 86 • Labour 560 • Operation and Misc. 120 • Transportation 180 Total Cost 1021 Revenue • Harvest: 17 bags. of 70 kg. at 4.60 BWP per kg Total Revenue 5474 **Profit 4453** **Cost-Benefit Ratio 0,23**	Cost • Tractor Rental 200 • Fertilizer - • Labour - • Operation and Misc. 50 • Transportation 750 Total Cost 1000 Revenue • Harvest: 4bags of 50 kg. at 4.00BWP per kg Total Revenue 800 **Profit -200** **Cost-Benefit Ratio -5**

Figure 6 shows that the subsistence farmer's agricultural production is characterized by a negative cost/benefit ratio. To get a more beneficial production capital investments are needed for hired labor, transport, and fertilizer. This was confirmed by CSF2 according to whom "*The main problem that the farmers in Lerala are facing is the lack of access to capital…*" These investments are difficult to make for the poorest households, especially given the risky condition for crop production due to the erratic rainfall. Considering the number of bags the average households consume each year, it is not realistic for subsistence farmers to sell their produce and this way accumulate capital to buy inputs. Therefore the farmer without sufficient capital for inputs, boreholes and tractors will not be able to gain a sufficient surplus to sustain their livelihood from agriculture.

Few farmers have tried to cope with this constraint by sharing their resources. A teacher provides capital to a farmer for ploughing in exchange for a certain amount of harvest. This is very compromising for both parties when a bad cropping year occurs (Junior, 2005). Many farmers barter natural goods instead of using hard currency as a survival strategy. Some farmers also use bartering to gain agricultural inputs. This explains the general lack of capital.

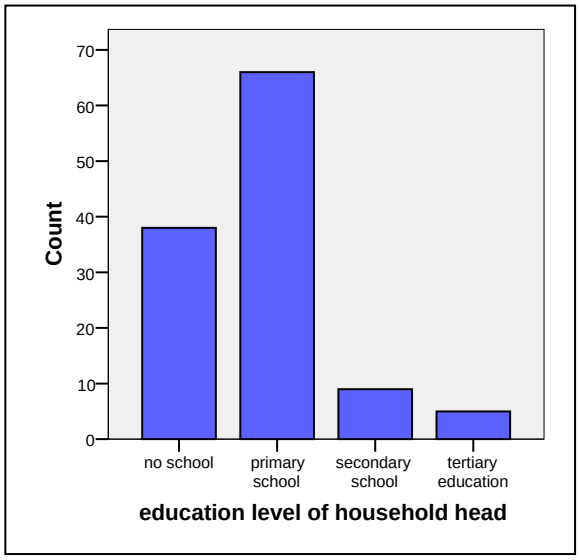
After 2001 government grants were turned into loans through The Citizen Entrepreneurial Development Agency (CEDA) and farmers were discouraged to invest in agriculture due to the lack of grants. This has resulted in larger dependence on external financial inputs to agriculture. A way

of getting this external source of input is from family members outside the household. Given the low feasibility investing in agriculture is not rational. In addition, the average household in Lerala are harvesting too little to support the household with food through the year.

3.4.2 Access to Credits

The way for the farmers to gain access to credits is through CEDA, which is meant to cater the needs of small entrepreneurs. CEDA offers funding for capital expenditure, in form of stocks or working capital in new and existing business ventures. In principle every citizen above 18 can apply to CEDA by submitting the requirements for the loan application. However, the requirements include detailed information on the corporate structure and management, project plans and a market analysis of the product anticipated to be sold. For farmers with limited education and understanding of the process, the requirements are unobtainable.

Figure 7 shows the education level of the household head, which for few households is higher than primary school. For these households it is difficult to comply the requirements without assistance but hiring a consultant for a small-scale farm business is not feasible.



Furthermore, according to CFS 2 the repayment period of the loan is too short and even the NAMPAD (National Master Plan for Agricultural Development) pilot farmer in town found it hard to obtain CEDA loans. So even though the government does provide access to capital through loans these loans are very hard to obtain, whereby they don't offer a solution to the capital constraint.

3.5 Markets

CSF 1 mentioned that having no access to market makes farmers reluctant and less motivated to invest time and capital in the field. They are just content with what they produce at the present. *If a*

buying station is accessible for the farmers in the village, they will be encouraged to put more effort to increase their production (CSF#1). The accessibility of markets plays an important role not only in motivating farmers' performance and competitiveness but also in maintaining the supply and demand for agricultural products. However, the market activity of crops in Lerala is stagnant. Farmers can sell products to milling companies and other buying institutions such as the government provided Botswana Agricultural Marketing Board (BAMB), which intends to buy farmers produce regardless of the quantity as long as it follows the quality standard. BAMB is responsible for both marketing and stocking/storing of agricultural products, and for having a substantial amount of grains to ensure food security throughout the country. The nearest BAMB is located in Serowe 124km away from Lerala. Selling the products to BAMB is a constraint to the farmers due to high transportation cost of more or less BWP750, which can not be compensated for because the price the farmers receive on their produce is low and discouraging (AD). However, some agricultural products, like watermelon and sorghum are commercialised into beer, which is am important source of income especially for the traditional farmers. Watermelon is also made into jam (Lerotse), which is sold by the Kgetsie Ya Tsie (KYT).

3.6 Labour

Both male and female farmers mention lack of labour as a constraint and the men were also concerned about hard work in the fields. The SPSS result shows a higher numbers of children and youth than the number of elders in the village. This is a constraint to agriculture because the elders mostly undertake farming. Recent statistics indicate that in 2002 48.674 people were infected with AIDS/HIV in the Central district (Autlwetse 2003). This raises additional concerns about the decreasing working group available for agriculture. On the other hand the rate of job seekers for Serowe/Palapye area was in 2001 approximately 15% (Autlwetse 2003). Therefore problems with lack of labour are not due to availability but beside the issue HIV/AIDS to the youth's lacking

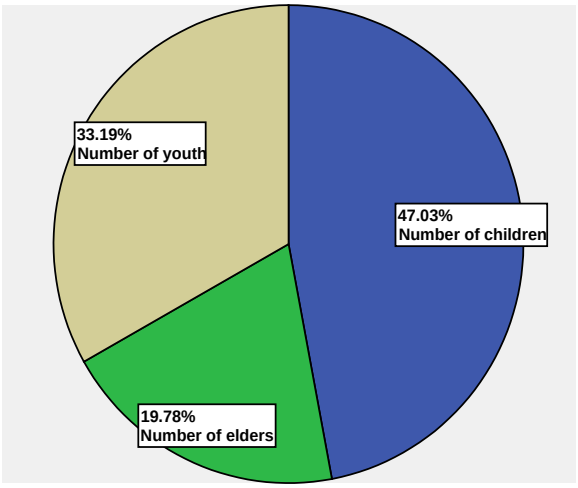


Figure above show the different age level in Lerala.

motivation for farming (focus-group). Even the few farmers who could afford to hire people for fieldwork found that the local youth were not interested in fieldwork on a regular basis. Instead farmers were anticipating hiring workers from neighbouring countries (NAMPAAD pilot farmer). According to the chief's interpretation, the lack of motivation was due to the characteristic of laziness in the youth (The Chief 2005). However, this statement doesn't reflect the reality faced by the youth. The cost benefit analysis shows that agricultural production doesn't provide a sufficient income for subsistence farmers. This is reflected in the agricultural labour under-utilization meaning that people are working full time but their contribution to the output is small compared to a minimum wage (Perkins et al. 2001).

The motivations for the rural-urban migration are reflected in table 6. The PRA-pair-wise ranking shows how the youth would choose between different opportunities found in town.

Table 6: Opportunity ranking

Opportunities	Facilities (F)	Jobs (J)	Life Style (LS)	Education(E)	Small Business (SB)
Facilities (F)		J	LS	E	F
Jobs (J)			J	J	J
Life Style (LS)				E	SB
Education (E)					SB
Small Business (SB)					

Results: Jobs (J) = 4, Education (E) = 2, Small Business (SB) = 2, Facilities (F) =1, Life style (LS) = 1

Looking for a job is the primary reason for migration to town followed by education. This is the exact opposite of the chief's perception of the young. In addition the youth don't consider farming as a civilized job in a world where increasing globalisation is influencing their life style (focus group interview). The opportunity of finding employment in the towns might not be higher. However, the disproportionately higher wages compared to agricultural wages create the necessary incentive for most young people in Lerala to go look for greener pasture in the towns. Unless, the agricultural production and thereby the benefits of working in the fields are increased through enhanced institutional and environmental management, the youth are unlikely to engage in agriculture in the future and the problem of lacking labour force will remain unsolved.

3.7 Access to land

Even though access to land was not mentioned in the agricultural constraints ranking some people did express that it was a constraint due to the high population expansion the last 10 years (AD, land overseer and Bane). For example, in 2004, the land boards reclaimed 16 fields because they were bordering residential areas (Land board chair 2005). That implies that even though access to land is in general not a constraint it might be a constraint to newcomers, which actually have an interest in agriculture.

Furthermore, under customary law, all citizens irrespective of gender are entitled to land, which is regulated through the land boards. However even though you can get a piece of land, the plots become less favourable over the years because they move further away from the village and are perhaps less fertile. We also found that there could be a great difference in how developed a field is when allocated. If the land is still bushed it is very labour intensive to get the land ready for planting, hence the quality and suitability of the available land differs. In addition, the preferable areas in the Tuli-block close to the Limpopo-river were taken under the colonial period by the white settlers and never given back to the local population.

Figure 9 shows a correlation between owning a field and owning cattle. This might be related to the fact that being able to crop the field is not only a question of getting access to a field but also having the necessary inputs to do so. This is supported by the observation that many fields were left unused, indicating that people didn't have necessary means to cultivate them, as is seen with CSF 1. The issue of land accessibility seems to be related to distribution and not physical limitation.

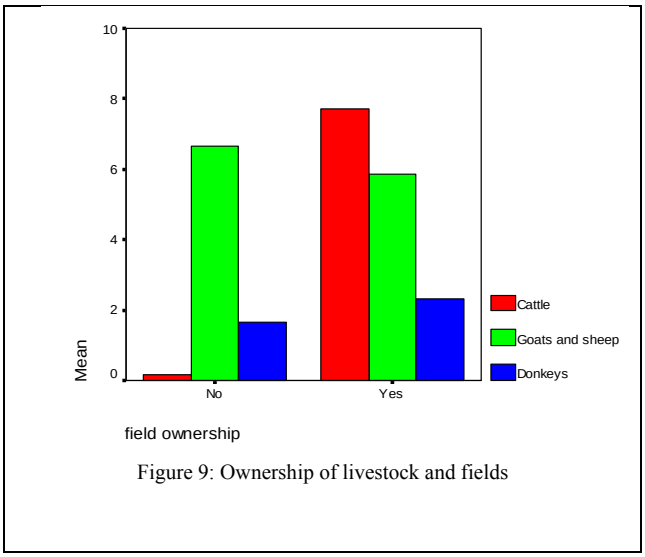


Figure 9: Ownership of livestock and fields

4. DISCUSSION POINTS

4.0 Introduction

As we have seen in the sections above there are a cluster of constraints linked to agricultural production in Lerala. In the following section we are going to argue, that everyone is not equal when facing these constraints. This will be done through showing how gender bias and poverty can limit agricultural practises. In the last part of the section we are going to discuss the government response to the agricultural constraints we have analysed.

4.1 Gender Production Gap

In Lerala women play a major role in farming activities since 60% of the households were female-headed households (FHHH). Based on SPSS 71% of the women are farming, however they produce only 39% of the total production. Figure 10 shows that male-headed household (MHHH) own up to four times as much cattle as the women. Cattle indicate wealth in Lerala. The fact that cattle ownership traditionally is a male biased activity could be the reason why women are disadvantaged in obtaining agricultural inputs.

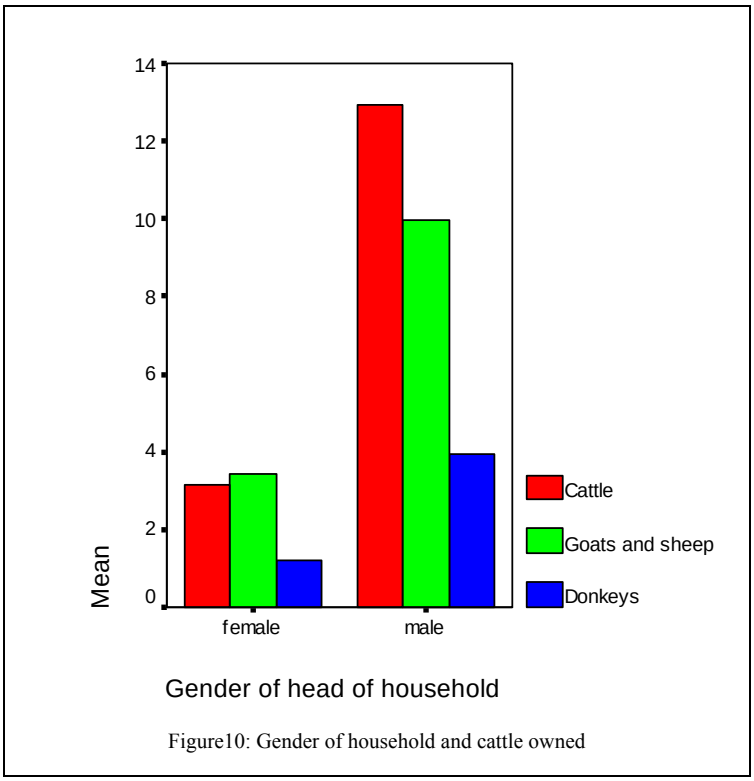


Figure10: Gender of household and cattle owned

Figure 11 shows that male and female own relatively equal amounts of fields, but FHHH household do not crop their fields as much as the MHHH. Combining figure 10 and 11 leads us to the assumption that FHHH are among the poorest in the village. These types of households are therefore those who lack resources necessary for crop production. They have little money to hire help, they are short of household manpower and they lack their own draft power. Larger households are also able to diversify their labor activities. In addition if they don't have a labour-migrating husband to contribute to the household they are unlikely to being able to produce.

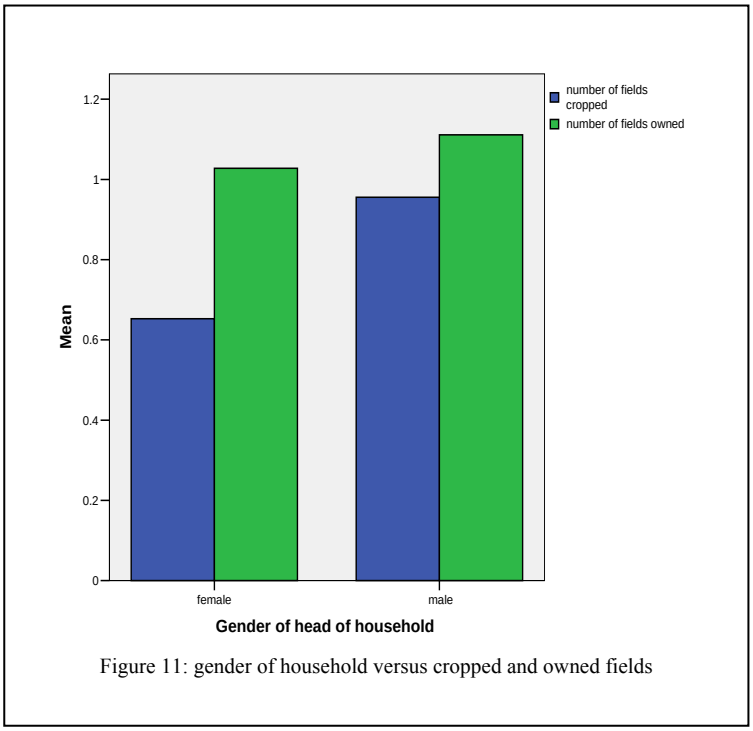


Figure 11: gender of household versus cropped and owned fields

CSF 1 who has only cultivated 1 ha since her husband died instead of 20 ha confirmed this. In addition, CSF 3 mentioned that she only cultivate her fields when she has money for ploughing. From these findings it can be concluded that there is a correlation between the disproportion of crop production between genders and the lack of access to the means of production.

In Lerala there has been an attempt to empower women through the organization KYT that offers micro-credit loans to women to promote the selling of veldt products. Although the future of the organisation is debatable it's worth noticing that no attempt has been made to empower women in agriculture. It could have been interested to investigate whether there are any female members of

the farmers committee. When we asked the AD he only gave us reference on male members of the committee, which indicates the lack of involvement of women in the committee.

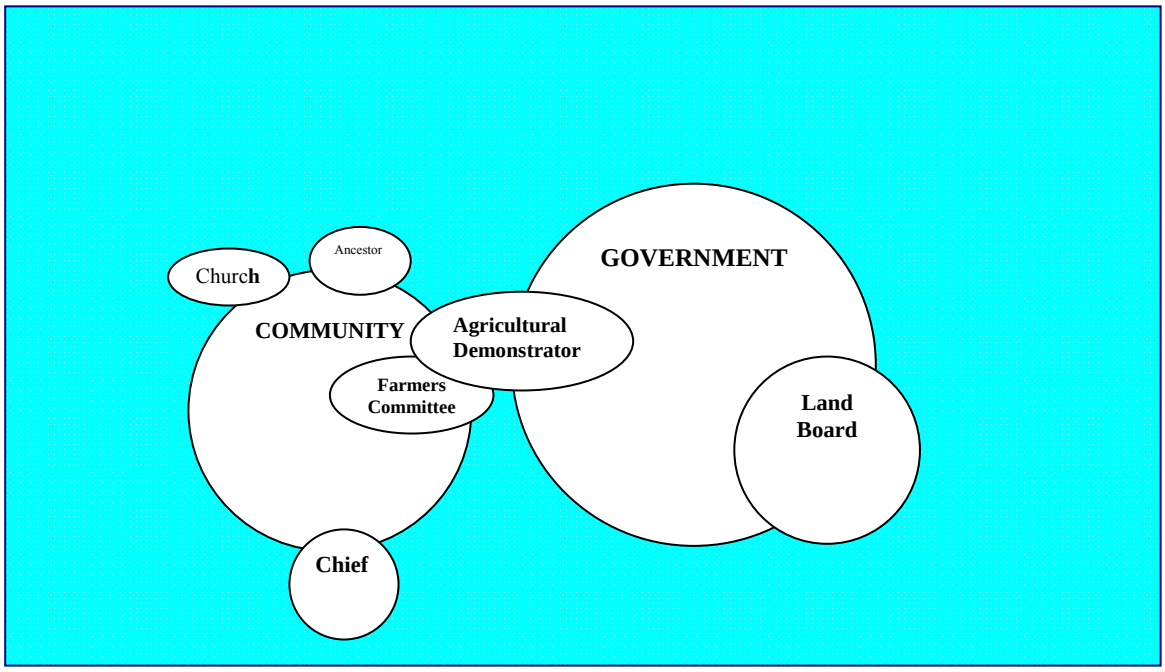
4.2 Institutional response

This section sums up on the different institutions affecting agricultural production in Lerala, which are shown in the Venn diagram below (figure 12). The government has the biggest influence on the production, which is reflected in the many government programs initiated through the years, such as FAP, ARAP, ALDEP and now NAMPAD. Many of these programs were short-sighted and didn't fulfil the anticipated improvements within the sector. However many people still benefit from the individual field fencing provided by ARAP and ALDEP. The currently running ten-year program, NAMPAD, offers technical assistance and advice for large-scale commercial farmers who have a field size no smaller than 150ha and are in a position to invest in necessary means to produce. This leaves out all subsistence farmers unless they group themselves. The problems with grouping in this context are related to risk sharing and the cultural focus on family units. In addition through the interviews we learned that very few subsistence farmers have even heard about the programme. NAMPAD documents predict eradication of some 50,000 subsistence farmers by the end of the project period. There is no suggestion to an alternative way of sustaining rural livelihoods. Consequently, at present time there is no government schemes to help the most unfavourable farmers. This is unreasonable considering Botswana being a country with a rapidly increasing growth. The government should take responsibility for all citizens and distribute wealth in order to meet the objectives of food security on the household level and for the subsistence farmer to rise above the poverty level. Addressing figure X it is striking that the government has the largest circle but yet provide nothing for the subsistence farmer, however the size of the government circle indicates the potential influence.

On community level the farmers committee and the AD are meant to address the problems farmers are facing which are also reflected in the diagram. However the farmers committee consists of a few wealthy men that tend to take advantage of the AD's time and resources, which could have been invested in the affluent farmer. CSF 2 illuminates this issue in his comment on the new AD, who is his brother-in-law and expected to assist him thoroughly in his horticultural irrigation adventure. The farmers committee represents a powerful elite who has the influence to negotiate in favour of

their own conditions oppose to the subsistence farmers. The poorest farmers are in a multi-constrained situation and the services provided from the AD are not appropriate for their situation.

Figure 12: Venn diagram of institutions influencing agriculture



The AD offers extension service to the farmers. For example, the government is informed of an outbreak through the agricultural extension officer in Palapye, which is informed by the AD who gets the information from the farmers in Lerala. This can be seen as a very long and time-consuming communication line, which could question the effectiveness of this procedure. CSF 1 confirms that the AD is very difficult to reach. Furthermore, the AD also offers training in farming practises. However, the lack of training in agriculture is only a small brick in a complex system, and which on its own cannot carry the fundament for agricultural production.

5. CONCLUSION

In this section we are going to give the conclusion to our research objective through answering the specific research questions.

1. The soil samples gave us indication of very poor soil fertility in the area; however it was not that severe in cases where organic fertilizer had been applied. Where AF was applied this was not done in sufficient amounts to increase soil fertility significantly. We observed that

using fertilizer was extremely rare in Lerala and the majority of farmers are likely to experience nutrient deficiencies of N, P and K. Farmers owning livestock have an advantage in their accessibility of manure however this was rarely utilized.

2. Water conservation management strategies are practiced in the in forms winter ploughing and row-planting, however both these methods require increased capital and labour compared to the traditional farming system. Overall the methods have no effect on crop production in Lerala as so few are practicing them; lack of information and required inputs hinder farmers from adopting the methods. Whether applying boreholes and irrigations systems have limitations in terms of environmental sustainability we are yet to discover but the economic sustainability and lack of technical knowledge are constraining the use.

3. Pests and weeds are constraining factors on the production, which only have labour intensive manual control techniques. The pest control provided by the government does not reach the farmers in a timely manner. Weeding is an activity mostly undertaken by women and given the women's disadvantage poses further constraints.

4. The choice of crops is well suited for the area. Drought tolerant crops are grown, except for maize, which farmers' say mostly is grown in wet years. Additionally some farmers tend to have a crop rotation where legumes (groundnuts and beans) are separated from other crops. These factors are beneficial for the cropping system. Changing the practise to row planting could be very beneficial given available capital.

5. According to the cost benefit analysis capital costs weight much higher than the capital benefits; this leads us to conclude that existing capital is essential to sustain agricultural production. The possibilities of obtaining capital through credit are very small considering the educational level applying for the CEDA loans require. Consequently, farmers with capital assets such as cattle are in a better position to liquefy capital than the majority of the subsistence farmers. Additionally, few farmers have access to a market, however due to low productivity very few farmers are in a position to sell parts of their harvest after supplying themselves. Lastly, low prices on agricultural produce are discouraging and limit the economic feasibility of agricultural production.

6. There is a lack of labour in farming for two reasons: A large number of people in the working age-group are no longer living or are sick primarily due to HIV/AIDS and younger generations are lacking motivation to pursue farming activities. The latter can be viewed in the perspective of globalisation where hand hoeing in 35degree weather is not an attractive activity. Furthermore, the underutilization of farming labour, high costs and low productivity of agriculture emphasises the point.

7. The poorest households are female headed due to small live stock ownership and few fields cropped. Hence FHHH are disadvantaged in access to capital to invest in agriculture. Crop production is more feasible for well-off farmers but remains important for those households without alternative sources of income. The subsistence farmers have to support their agriculture with additional income. Hence farming is only feasible for the relatively well-off farmers with cattle. These requirements exclude the majority of the poor rural households. The education level has an influence on farmer's access to credits making it practically impossible for the majority of the farmers to obtain this access because most heads of households have no higher than primary school education.

8. It is questionable whether access to land is a constraint to agriculture. Agricultural land has been reduced in size due to population expand and officials emphasize this as a concern. On the contrary large arable land areas are left unused indicating that people who already have fields don't fully utilise the potential of the lands. Furthermore, accessibility to favourable plots is decreasing over time and sometimes labour-intensive activities are needed to debush the land.

9. Currently the agricultural programmes are mainly aimed at large scale farmers, who are already in a position to invest the necessary means to produce, and don't provide improvement for the livelihoods of the subsistence farmers. The local institutions aimed at supporting the subsistence farmers are neither providing the necessary services to help the poor farmers to alleviate the poverty trap. In addition the poor lack the necessary political resources to do anything decisive about their own situation.

6. RECOMMENDATIONS

The recommendations stated below where revealed through a brainstorm of possible solutions for the each of the constraints identified in the field using a bottom up strategy. When summing up on all the solutions some issues were reappearing and these are described below.

Agricultural extension service in Lerala must be increased to aid the farmers in the battle against the environmental conditions. Increasing the number of ADs is necessary as well as providing them with a vehicle due to the distances between field and residence. Differentiation could be made between subsistence farmer advisors and farmers that could pay for advice e.g. for horticultural productions. Advice on conserving soil moisture and irrigation systems must be made easier available together with fertilizer recommendation and most importantly promoting the application of organic manures. Weather forecasts should be made available. Faster reaction against pest outbreaks and promotion of alternative cropping systems like row planting should be emphasised where appropriate.

More visible and stable institutions must be created within Lerala to strengthen the farmers' awareness of government programs and how to obtain the potential benefits. Farmers' cooperatives should be established both as small and large groups to address the different levels of need. Especially the women must be strongly represented in these groups since the least fortunate tend to have least political resources to influence their situation. The issues of FHHH and their access to livestock/organic manure must be addressed on a community level to raise the conditions for women to increase the soil fertility on their fields and consequently improve their production. This could be done by representation in the farmers committee and to offer micro-credit schemes to overcome the lack of inputs.

The division of the 3 types of common land hinders the integration of livestock and arable farming, which is an important element in a low/no input farming system. Attempts must be made to integrate livestock on the arable fields with emphasis on the utilization of nutrients. This point however demand much more than increased AD service but a change in the Tribal Land Act to allow livestock grazing on the arable land and erection of kraals on these lands. Additionally the land boards should consider redistribution of unused fields to new-coming farmers with motivation

and not just inputs to farm. In redistribution process distinction should be made between farmers not having the motivation and not having inputs

Improved market conditions are also needed if farming is to become more cost-beneficial. Having a corn bank on the village level could reduce the high transportation cost and the revenues received from banking interest could provide a micro-credit scheme. In addition, more credit schemes should be provided both from private and government institutions.

7. ACKNOWLEDGEMENTS

In the making of this report we would like to pay respect to the following people. Our counterparts from the southern African universities: Bonolo Bamba, Senwelo Isaacs, Marea Motsepe and Dorah Mdluli were a great assistance in the fields. Additional respects are paid to the staff member of SACUDE –DUCED programs: Dr. Trevor, Dr. Kath, Prof. Lado, Mrs Kgabung, Prof. Sebego, Prof Setshogo and the Botswana Ph.D students.

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9. APPENDICES

A: Seasonal Calendar

SEASONAL CALENDAR

ACTIVITIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ploughing												
Broadcasting												
Cooking												
Guarding the Field												
Hoeing												
Driving Away Animals												
Scaring Birds												
Storage Preparation												
Harvesting												
Husking												
Storing Grains												
Cutting Trees												
Fencing												
Equipment Check-up												
Seeds Planning												
Tilling of Soil												

B: Interview Guidelines

1. Overview of the agricultural practices in the village.
2. Duty of AD.
3. Do the farmers come and ask for advice.
4. Response of farmers to the advice.

Ecological Constraints of Agriculture

5. Use of fertilizer, kraal manure and how much is recommended.
6. Pest and plant diseases
7. Treatment and protection
8. Crop rotation, row planting and intercropping
9. Irrigation

Socio-Economic Constraints

10. Importance of agriculture on the livelihood
11. Seasonal Distribution
12. Labour Migration
13. Youths priority
14. Access to market and credit
15. Government services

Institutional Constraints

16. Funding Institution
17. Changes in policy
18. Access and distribution of land
19. Insecurity of ownership
20. Potential conflicts
21. Gender inequality
22. Future Agricultural plans
23. Population expansion vs. agricultural production
24. Correlation between HIV/AIDS on agricultural production
25. Government Programme

C: List of Informants

The following informants were used in the fields:

1. CSF 1: Sherney Thuso
2. CSF 2: Mr. Poloko
3. CSF 3: Killet
4. CSF 4: Mr. Lekula
5. Farmers Committee Secretary: Mmerki Duelang
6. Agricultural Demonstrator: Mr. Amos Masulthe
7. Land Overseer: Ezekiel Nkegetsi
8. NAMPAD Pilot Farmer: Mr. Molemogi
9. High School Kids Focus Group
10. The Chief: Mr Moroka
11. Subsistence Farmers: Elysabeth kereditse, Emily Masilo, Seponie Bane, Garesenkwe Baakile, Mr. Molefe
12. Ministry of Agriculture, NAMPAD advisor: Cecilia Kgomoto
13. CEDA Development Officer: Mr. Mogorosi
14. Local Politician: Mr. Cornelius and Mr. Setlon
15. Land Board Member
16. Interpreter: Mr. Colin
17. Teacher: Junior

D: DIARY OF ACTIVITIES AND FIELD SCHEDULE

Marcel Tutor Ale **January 14-25, 2005**

DATE	ACTIVITY	RESULTS
Jan. 14 (Friday)	• Arrival in Lerala • Conversation with the local Policeman, Chief Clerk and several women.	• Accommodation • Getting oriented with local greetings " Domela" and others Tswana words
Jan.15 (Saturday)	• Handing out general questionnaire survey. • Conversation to a P.E. teacher. • Conversation with women and Interpreters	• 8 questionnaires completed. • Got information on sharecropping system in the village, overview on farming system and methods used. • Informed about old Community Cooperative Market.
Jan. 16 (Sunday)	• Village and Field Orientation • Preliminary interview with Mr. Kgomotsi Lekula (Case Study Farmer) • Group Meeting	• My first contact with a local farmer from the village. Slight interview about his field, types of crops planted, area and methods he used. • Gathered relevant information on farming system in Lerala, marketing, prices and related problems affecting farmers and crop production. • Discussion for the first group feedback plus scheduling
Jan. 17 (Monday)	• Interview with the Chief, together with Signe Marie and Dennis. • Group Meeting • PRA – Problem Ranking • PRA – Seasonal Calendar • Interview with group of youths together with Dr. Traver and Signe Marie plus interpreter • First contact with Ms. Thuso (Case Study Farmer)	• Overview about the village, agricultural practices, institutions, future plans and issues concerning the youths. • Discussion on PRA techniques and scheduling • 9 problems listed and ranked by male farmers. • Lay-outing of seasonal calendar for male was done. • Got informed on what youth's wants and desire why they go to town plus heir interest on farming. • Made appointment for field visit and interview.
Jan. 18 (Tuesday)	• Interview with Ms. Thuso together with Signe, Isaac, Marea and Andreas • Infiltration test and Soil Sampling. • Visit Seleka Farm and Interview the Foreman	• Informed about the functions of BAMB and farmers marketing strategy. • Soil sample on 2 fields, namely her Mom's and her Brother. • 42 workers and 9 of those from Lerala • Gather information about

	• Preliminary interview with Mr. Ismael Poloko (Case Study Farmer)	economic constraints, marketing to BAMB, NAMPAADD and farmers strategy during drought.
Jan. 19 (Wednesday)	**DAY OFF**	• tired
Jan. 20 (Thursday)	• Field Visit to Mr. Poloko and interview. • Infiltration test and Soil Sampling • Field Visitation to Ms. Killet • Infiltration Test and Soil Sampling	• Identified the crops and the practices in his field like irrigation and chicken dung application • Gathered soil samples and infiltration test done • Fallow farm • Gathered soil samples and infiltration rate test done.
Jan. 21 (Friday)	• Interview with Mr. Lekula (CSF) and field visitation • Soil Sampling • Preliminary Soil Analysis	• Informed about the trend in arable farming in Lerala • Gathered soil samples • Ph values and Conductivity
January 22 (Saturday)	• Opportunity Ranking with youths. • PRA - Venn Diagram • Football Match	• 4 participants, 2 male and 2 female • Farmers and few women participate in the process. Successful • We won!
Jan. 23 (Sunday)	• PRA - Matrix Ranking • Cattle post Visitation and interview with a boy • Measuring the Borehole	• Youths as stakeholder • Owned 2 Donkey • 13 metres deep
Jan. 24 (Monday)	• Group Meeting for the presentation on Community Feedback • Interview with Cornelius • Interview with former AD	• Organized • Informed about NAMPAADD, agri-practices, institutions and livelihood strategy during drought. • Gathered information about trend in Agriculture in Lerala
Jan. 25 (Tuesday)	• **GOODBYE LERALA**	

Signe Kynding Borgen

Date	**Activity**
Friday 14th of January	Arrival to Lerala, Welcome and accommodation
Saturday 15th of January	Welcome Ceremony by the Chief and Common questionnaire survey
Sunday 16th of January	Orientation trip w. Kath and Trevor, met local farmer Samuel Paswane and made appointment for interview with agricultural demonstrator Amos Mashunthe
Monday 17th of January	Interview secretary of the farmers Committee:

	Mmerki Duelang. Making action plan for the week
Tuesday 18th of January	Interview with CSF 1: Sherney Thuso, GPS points of fields, soil samples and infiltration test. Interview with our interpreter Colin
Wednesday 19th of January	Day-Off: lovely safari and Brey at Stevenson Farm
Thursday 20th of January	Interview with CSF 2: Mr. Poloko, GPS of field, soil samples and infiltration test. Interview new-coming farmer
Friday 21st of January	Soil samples and interview with CSF 3: Killet Interview with CSF 4: Mr. Lekula, GPS of field, soils samples. Perform soil tests in thunderstorm
Saturday 22nd of January	Typing up interview summaries and attempt to disseminate knowledge Soccer Match
Sunday 23rd of January	Interview with Land Board Member Interview with 2 affluent subsistence farmers. Interview with agricultural demonstrator of neighbouring district.
Monday 24th of January	Visit to Kgetsie Ya Tsie. Interview with teacher at the brigade and politician: Cornelius. Community feed back session
Tuesday 25th of January	Back to Gabs

Signe Marie Cold-Ravnkilde

Friday 14th	Arrival in Lerala and welcoming by village committee and chief
Saturday 15th	Common questionnaire survey
Sunday 16th	Church, made appointments with the AD and names of farmers and field orientation trip
Monday 17th	Interview with the chief, Problem ranking women. Group feedback
Tuesday 18th	Interview with NAMPAD pilot farmer, a local politician, 2 subsistence farmers interviews
Wednesday 19th	Day off at the Limpopo-river
Thursday 20th	4 subsistence farmers interviews, Seasonal calendar and Venn diagram women. Compiling information and Mid way presentations
Friday 21st	NAMPAD pilot farmer follow up, Interview with AD
Saturday 22nd	Focus group interview with the youth, Land overseer

	interview
Sunday 23rd	Interviews: Land board member, 2 subsistence farmers, agricultural demonstrator of neighbouring district
Monday 24th	Visit Kgetsie Ya Tsie, interview Cornelius teacher at the brigade and politician. Community feed back session
Tuesday 26th	Leave Lerala for Gaborone

E: THE SYNOPSIS

List of Content

1. INTRODUCTION

1.0 BACKGROUND

Botswana is an arid country in which less than 5% of the land is cultivable. Food-crop production covers less than one-third of the national consumption in Botswana. Aims for self-sufficiency in basic foodstuffs are far from being realised. The political awareness of the low productivity levels of the agricultural sector since the country's independence in 1966, has led to the implementation of agricultural programs in the middle of the 1980's in form of the ARAP (Accelerated Rain fed Arable Programme) and the ALDEP (Arable Lands Development Program). However, in spite of these initiatives, no positive change has been recorded for the agricultural sector (Seleka, 1999).

Lerala is situated in one of the best agricultural zones of Botswana and most households practise some agriculture. The basic agricultural system (with a number of variations) is for people to live in villages and to grow crops in fields, which may be near the village or further away (Whiteside 1997). Sorghum is the main crop together with maize. Beans, groundnuts and wild melons are also grown often intercropped. Households generally have 5-10 ha of fenced fields at the perimeter or outside the village itself. Animal traction or tractor mainly cultivates the fields. Most crops are broadcasted although row planting has been encouraged in recent years and is practised by a limited number of farmers in Lerala. The major constraint on the agricultural production in this semi-arid ecological zone is the rainfall. In Lerala precipitation amounts to between 350 – 500mm annually (Atlhopheng et al, 1998) which is a serious hindrance for cultivation of many crops. The minimal use of artificial fertiliser in Semi-Arid Africa is often due to the lack of credit possibilities but also due to the low cost efficiency of investing in artificial fertiliser as erratic rainfall limits crop growth, uptake and timely release of fertiliser. In addition to low soil water content, poor soil fertility and pests and diseases are considered the primary ecological constraints of agricultural.

Furthermore, distribution and availability of labour are among the major social strains on agricultural production. Among other things, the lack of labour force is reflected in labour migration, where, especially the young people are moving away from the rural agriculture into industries and other sectors within the urban areas (NAMPAAD 2002). This tendency stems from both the need to find alternative income

Among other things, land entitlement is the security measure to gain access to credit. Credit institutions in the form of rural banks or credits cooperatives can stimulate rural growth, employment and increase farmers' incomes through greater crop diversification and enhancing sectors competitiveness. Selling farmers harvest directly to the market without the intervention of the middlemen. This can enhance confidence to products and thus maintain the quality of goods. However, in the case of Botswana, the middlemen is the one who buys bulk quantity and sell it with big mark-up to gain the profits at the expense of the economically poor farmers (FAO, 1998) strategies and, for various reasons, the decreasing attractiveness of agricultural production.

Before colonisation, Botswana had customary procedures and rules governing land tenure. These customary rules have served the purpose of securing the land rights of the great majority of the populations for generations. In Botswana the customary rules provide the basic framework of customary land law and most occupied land in rural areas is still held under tribal or customary tenure. However, since the 1970's major privatizations of the communal land has been performed in form of the Tribal Grazing Land Policy (TGLP) and its reinforcement National Land Policy on Agricultural Development (NPAD). This process has enabled the local elites to centralize decisions about land in the so-called land boards, which on the overall has been to the benefit of the large

holders of livestock. This has made access to grazing land more complicated and increased the cost of keeping cattle. Hence, small farmers have lost access to draft power and the integration of livestock and crop production of has become more difficult. Consequently, many households have been forced to drop out of agricultural production altogether because mixed agro-pastoral farming is no longer possible (Cullis and Watson 2004). These potential conflicts over land, due to the power of the elite to allocate land in their own favour, are pushing people to cultivation of marginal land.

1.1 Problem definition

The objective of this report is to assess the importance of agriculture for local livelihood in Lerala and to analyse the major ecological, socio-economic and institutional constraints to agricultural crop production. Through an interdisciplinary approach, we are going to address this objective in a threefold manner. First, we will analyse the agro-ecological conditions, focussing on soil nutrient status, water conservation management, pests and diseases. This investigation will also address issues such as soil amendments/fertilizer use (biological and artificial), cropping systems/practices and post-harvest techniques and storages. The second step is to analyse the socio-economic conditions necessary for maintaining crop production over time. This includes analysing the labour availability and distribution, farmers' access to market and credit institutions, distribution of marketable products (middlemen activity) and farm equipments. Lastly, an analysis will be made on the institutional constraints to agricultural production. This means analysing the land tenure system, who have access to land and depending on the land tenure category – tribal, state or freehold- what agricultural practises the land rights allows.

Throughout the report the following is going to be our problem definition and specific research questions:

What are the main ecological, socio-economic and institutional constraints hindering agricultural crop production in Lerala?

We will answer the problem definition through answering the following research questions:

1. What are the main ecological constraints to agricultural production in terms of soil fertility status, water balance and crop management practices?
2. What are the main social constraints of agricultural production in terms of labour and economic availability?
3. What are the institutional constraints to agricultural production in terms of access to land?

1.1.1 Elaboration of problem definition

Question 1 will focus on poor soil fertility, lack of soil moisture and pests and diseases through answering the following questions:

a. What is the nutrient status of the soil and are there risks of nutrient deficiencies?
b. What kinds of water conservation management strategies are practiced and how do they affect crop production?
c. What are the main agricultural pests, how severe is the impact thereof and what measures can be made to decrease the impact?

Additionally these sub-questions will be investigated if they are found have an impact on the main questions above:

d. If soil amendments to the agricultural system (artificial and biological inputs) are aiding to increase sustainable crop production?
e. How do cropping systems in terms choice of crops and rotation influences agricultural production?
f. Can improvements be made on post harvest techniques and storage systems in order to increase the quality of production?

Question 2 focuses on the labour and economic availability to agriculture through answering the following questions:

a. What is the seasonal distribution and availability of labour for agriculture?
b. How does the labour availability relate to gender, wealth, age and education?
c. How does the farmers' access to market, credits (e.g. sharecropping) and farm equipments influence agricultural production?
d. Does lack of ownership affects access to credit and thereby limits the possibilities to invest in agricultural production?

Question 3 focuses on the land tenure system that determines the availability of agricultural land through answering the following questions:

a. What is the spatial distribution of a farmer's agricultural land?
b. How is land quantity and distribution reflected in social categories (gender, wealth and education)?
c. What are the motivations and extend of fenced agricultural land?
d. Who decided how land is managed in Lerala?
e. How does the relationship between state law and customary law on land tenure in Lerala affects agriculture?

1.1.2 Limitation

In order to strengthen the focus of the report we are concentrating upon issues directly related to agricultural sustainability. The fact that 33% of the working population has HIV imposes severe constraints on quality and quantity of agricultural labour available over the years. However given the limitations of this report we will not investigate conditions of health in terms of the HIV/aids situation although this is realised to be one of the major social hindrances to sustaining any livelihood practise in Botswana today. Furthermore, analysis of agro-forest products, the rate of land degradation and the changes in landscape over time is beyond the scope of this paper to investigate.

2. METHODOLOGIES

2. 0. Introduction

In the following section we are going to clarify what methods we are going to make use of in order to answer the overall problem formulation and the listed research questions. For the investigation of the major constraints linked to sustaining the agricultural crop production in Lerala, we have chosen a mixture of soft and hard science methods. This is necessary when approaching agricultural research with system thinking, in order to provide meaningful interpretations of complex and messy situations such as agricultural practices (Wilson, 1988). A full overview of the methods used for this field research is provided in the Data Collection Matrix in Appendix A together with information on the focus, topic, data, source and time frame of the information of interest. The uses of methods include questionnaire, qualitative interview and PRA methods (Diagrams, flow chart, seasonal calendar, rankings, mapping and transect walk). Soil tests are being used primarily to obtain some indications of the nutrient status of the soils and soil water content. In order to incorporate the data gathered by triangulation, it is necessary to obtain both qualitative and quantitative results of the assignment. In the following section we will describe what methods will be applied for the different research objectives. The precise execution of the methods will be described in the appendices.

2.1 Overall methodology

2.1.1 Case Studies

The research objectives stated in the problem definition will primarily be illuminated and answered through case studies although supported by the use of a general questionnaire. The choice of representative case studies is a central element of this report because it contributes to the practical empirical knowledge of the concrete agricultural practises in the context of Lerala, Botswana. The election of farmers for the case studies will be done according to comparability of biophysical characters but also according to the social criteria of income level. The latter means that we will pick 3-5 households, which include a poor, an average, and a rich household in order to compare according to income level. The strength of the case study is, that the analysis of a particular phenomenon in its own context allows a sense of reality, which can contribute to the understanding of the phenomena, which are being investigated (Flyvbjerg 1991). Nonetheless, it can be difficult to generalise on the basis of case studies, and we are aware of the fact that working in debt, to a certain extend, is at the expense of the width.

2.1.2 Questionnaires

A common questionnaire has been developed in collaboration with the 3 other research groups engaging in the field study in Lerala, Botswana of January 2005. The questions regarding agriculture are attempted to be fairly simple without any sensitive issues. The questions are represented in Appendix B.

The purpose of the questionnaire is to obtain some general information on the livelihood strategies in Lerala and correlations within the specifics of our research on the agricultural constraints will be drawn from treating the questionnaires with the use of Statistical Package for the Social Sciences (SPSS) described by Babbie (2002). The usefulness of the questionnaire is to understand the broader context of the issues that influence agriculture, to get an overview of the general situation and perhaps discover interesting key informants. The general questionnaire will furthermore allow us to determine the social distribution of land in relation to social categories such as gender wealth and education, which is directly linked to the questions concerning land tenure.

2.2 Methods to Investigate the Ecological Constraints

2.2.1. Soil Nutrient Status and Risk of Deficiencies

The backbone of investigating the ecological constraints of agriculture is the use of soil samples. The soil samples will be taken from our case study farmers' fields and tested to give the following information:

- Total C and N contents of the soils
- pH measurements
- Phosphor, potassium and what ever else we can measure on-site (Mg, Mn?)

In addition we would like to dig holes, if allowed and possible, in order to get a view of the soil profile and attempt a soil classification (Appendix C).

However additional methods are needed in order to understand what reasons, beside physical soil properties, might lay behind the fertility status of the soil. To discover this, semi-structured interviews will be used in addition to the PRA methods of common transect walk (Appendix D) where the crops on the field will be examined for deficiency symptoms. In relation to nutrient status the common transect walk will perform as a crop evaluation, which is preferably done with the farmer himself. Additional PRA methods will be used to investigate the nutrient inflows and outflows of the agricultural systems of the case studies. For this matter we would like to facilitate a PRA flow chart of farm nutrients (Appendix E).

Illumination on topics such as fertilizer applications, recycling of crop residues and tillage practices will be given somewhat through the questionnaire but primarily through semi-structured interviews. These issues are treated in relation to the soil fertility constraint but also in relation to water conservation practices and in the sub-questions of soil amendments. However the importance of these topics in relation to nutrient mineralization is inevitable. Information about the use of semi-structured interviews is found in Appendix F along with a tentative interview guide.

2.2.2 Water Conservation Management Strategies

A small number of farmers in Lerala practice conservation tillage. One of these farmers will be selected as a key informant and through a semi-structured interview (Appendix F) we will investigate the details of this tillage practice, the circumstances of implementation and the impact it has had on the agricultural production. In this relation we will need some general information regarding the productivity of the arable system in order to compare this with our case study farmers that don't practise conservation tillage. (If it is possible we will choose a case study farmer that practises conservation tillage, however we don't know the exact extend of this practice).

In addition to this we will make use of a hard science method (Gravimetric Method in Appendix C) to estimate the water balance and the soil water content of the fields. The water balance within the confines of the fields is a useful concept for characterizing, evaluating any surface irrigation. Other important parameters such as porosity, soil saturation, dry weight moisture fraction, bulk density and its specific weight will be identified. The relationship of these parameters are vital in measuring Soil Moisture Deficit which is necessary in evaluating the importance of water conservation management and to what extent should it be applied in the field.

2.2.3 Pests and Diseases

The major pests and diseases roaming in Lerala will be identified through a semi-structured interview with the agricultural extension officer related to Lerala. In this interviews information should be obtained about what kind of advice farmers are given regarding the fighting these pests (e.g. insecticide & fungicide recommendations). This information will also be requested from the case study households or an agricultural group chairman (Appendix G).

PRA ranking will be used to identify what the farmer considers to be the most important pest problems existing in Lerala. This will be done on individual basis with our case study farmers or if possible a small focus group will be formed and asked to rank the pest and disease problems identified from the interviews. Please view Appendix H for the details on the PRA ranking.

2.3 Methods to Investigate the Socio-economic Constraints

2.3.1 Labour Availability and Distribution

The questionnaire is used to get a general overview on labour availability in relation to gender, wealth, age and education. In order to identify the seasonal distribution of labour we are going to make a PRA seasonal calendar. The trends of migration will be addressed through a collection of in debt qualitative interviews of both young and elder people in the area. These interviews will enable us to understand the reality surrounding the agriculture labour force and the reasons behind choosing livelihood strategies in today's Lerala.

2.3.2 Economic opportunities through access to market, credits and farm equipment

The questionnaire together with the transect walk will be used to get data on how many households owns farming equipments, how many households sell or keep their harvest, and to identify how many households have access to market (Appendices B & D). During the case study we will conduct a semi-structured interview to gather in dept information about who owns agricultural equipments and the economic status of the household. Information about the market situation, the flow of products, post harvest technique used in the area and storage technique is likewise addressed through case study interviews.

2.4 Methods to Investigate the Institutional Constraints

2.4.1. The Spatial Distribution of Land

The questions regarding the spatial distribution of land are going to be addressed through the common transect walk (Appendix D) and sketch mapping (Appendix J). Aerial photos will furthermore be used to assist these methods. These methods will first of all; develop our basic understanding of the geography of the area and organize the local landscape into broad tenure categories, tribal, state or leasehold. The specifics motives behind fencing of agricultural land will be addressed in qualitative interviews. An interview guide of the information that needs to be gathered in relation to land tenure effect on agricultural practices can be viewed in Appendix G.

2.4.2 The Social Distribution of Land

The questions about the social distribution of land in terms of who owns how much land, whom uses the land and how does ownership relate to social categories such as gender, wealth and education are going to be answered by the quantitative data collected in the questionnaire (Appendix B). Furthermore, the social impact of the land distribution on the local farmers is going to be addressed in qualitative interviews.

2.4.3. The Management of Land in Lerala

The questions of how is land managed in Lerala, and how the legal framework in terms of the relationship between state law and customary law on land tenure affects agricultural production in Lerala, are primarily going to be answering through interviews with key informants and by use of a Venn diagram over the relevant institutions See appendix K. The key informants on this matter will consist of the local chief, representatives from the relevant land board, and if possible, key government officials. Furthermore, the local perspective on the institutional framework will be

reflected by informants from our selected case studies. Finally, the necessary background information on the legal framework is obtained through literature of relevant reports and official documents.

2.5 Concluding Remarks

The methods described in the previous section aim at gathering sufficient data to justify the answer to the problem definition. The conclusions of the report will reflect the choice of both research questions and the methods used to acquire the answers. In summary, this will give us a multi-dimensional background in order to evaluate the sustainability of agricultural production in Lerala including the ecological, socio-economic and institutional aspects. The various aspects might be viewed separately, but the objective of the final report will likewise be to show how these aspects are interlinked and influence on each other.

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4. APPENDICES
Appendix A: Data Collection Matrix

Focus Area	Topic	Data	Method	Source	Time Frame
Soil Fertility	Soil Nutrient Status	Total C & N	Lab analysis	Researchers	1-2 days
		Crop nutrients/deficiency	Transect Walk	CSF (case study farmer)	3-4 hours
	Soil type	Classification	Hole digging (field)	Researchers	3-4 hours
		pH measurement	Field test	Researchers	2-3 hours
Crop Management	Cultivations	Ploughing	Questionnaire, Interviews	Respondent, CSF	1 day
		Implements	Interviews	CFS	2 hours
		Draft Power	Questionnaire, Interviews	Respondent, CFS	1 day
Water Conservation	Soil water content	What is the ability of the soil to hold water?	Gravimetric test	Researcher	2-3 hours
	Conservation tillage (CT)	What kind of CT, time span?	Interviews	KI, CSF	2-3 hours
	Soil Amendments	Plant residues	Interviews	KI (key informant)	2 hours
		Farm Yard Manure	Questionnaire, Interviews	Respondent, KI	1 day
		Artificial Fertilizer	Questionnaire, Interviews	Respondent, KI	1 day
		General nutrient inputs & outputs	PRA flow chart	KI (key informant)	6 hours
Pest & diseases		What types?	Literature, interview	KI	1 day
		How severe?	PRA ranking	KI–group, CSF	2-3 hours
		What is done for protection?	Interviews	CSF, KI	1 hour
Weeding	Spraying		Interviews	Respondent,	1 hour
		With what?	Interviews	KI (key informant)	1 hour
		Manual? How often?	Interviews	KI (key informant)	1 hour
Labour					
	Labour availability	Seasonal distribution	PRA seasonal calendar, interviews	KI (key informant)	2-3 hours
		What influences the distribution?	Interviews	KI (key informant)	1 hours
		Migration	Interviews	KI (key informant)	1 hours
Econ. Importance					
	Income	How many household have AC as primary income	Questionnaire	Respondent	1 day

	Subsistence	How many household have AC as subsistence	Questionnaire	Respondent	1 day
	Income	How much is earned from ac	Questionnaire Interviews	Respondent, KI	1 day
	Investment	How much is invested in ac	Questionnaire, Interviews	Respondent, KI	1 day
	Harvest	How much?	Questionnaire, Interviews	Respondent, KI	1 day
The spatial distribution of Land		Where is agricultural land found?	Sketch mapping, transect walk and aerial photos	KI, and aerial photos	2-3 hours
		Fencing	Sketch mapping, transect walk and aerial photos	KI, and aerial photos	2-3 hours
		Location of water sources	Sketch mapping, transect walk and aerial photos	KI, and aerial photos	2-3 hours
		Type and location of farm lands	Sketch mapping, transect walk and aerial photos	KI, and aerial photos	2-3 hours
		Distribution of Land use	Sketch mapping, transect walk and aerial photos	KI, and aerial photos	2-3 hours
The social distribution (SD) of land		Who owns how much land	Questionnaire, Interviews	Respondents, KI	1 day
		Who uses land	Questionnaire, Interviews	Respondents, KI	1 day
	How does SD relate to:	Gender, Wealth, Education	Questionnaire, Interviews	Respondents, KI	1 day
	Power relations	Who controls over land?	Venn diagram	Respondents, KI	2 hours
Legal Framework	Land tenure system	Rules of land tenure?	Literature review	Researcher	1 day

Appendix B: Questionnaire

HOUSEHOLD

Informant + head of household

Gender of informant: Male ☐ Female ☐

Age of informant: _____ years

Is the informant the head of family? Yes ☐ No ☐

Gender of head of family: Male ☐ Female ☐

Age of head of family: _____ years

Education of head of family / number of years in school:_____

Is the head of family living in the house?
Yes ☐ No ☐

People living permanently in household:

Number of people living permanently in the house: _____ people

Number of adult men in the household: _____ men

Number of adult women in the household: _____ women

Age of people living in house *(write number of people in each category)*:

0-5 years	6-15 years	16-30 years	31-55 years	55- years

Number of 6-15 years old who are NOT schooling? _____ children

INCOME + AGRICULTURE + CATTLE

Number of people contributing to the household economy living outside the household?

Number of people with a regular salaried income (name the type of jobs)?

Number of people with a regular business (name the type of business)?

Number of elders with a regular pension?

Ranking of some sort…not sure what that's referring to…

	Number owned	Number sold last year	***Quantity of milk sold?***
Cattle			
Goats			
Donkey			

	Quantity produced	Quantity sold last year (note unit)
Maize		
Sorghum		
Groundnuts		
Beans		
Pumpkins		
Sweet melons		
Others		

What tillage method did you use last year? (More one option is possible)

Tractor drawn	Animal drawn	Ploughing	Hand hoeing

Do you own a tractor?	
Do you own an ox-cart?	
Did you use kraal manure on your fields last year?	
Quantity of kraal manure used last year?	
Did you use artificial fertilizer on your fields last year?	
Quantity of artificial fertilizer used last year?	
Did you use any chemical input (pesticide, etc.) last year?	
Did you remove all plant residues from your fields last year?	
Did any cattle graze on your fields last year?	

How many fields do you crop?	
Do you have any fields that you do not crop?	
Do you crop any fields that you do not own?	
Total area of fields:	
Do you practice crop rotation?	

VELD PRODUCTS

	Collected by household members for own consumption?	*Sold by household members?*		*Bought by household members?*
		To KYT	*To other*	
Timber				
Fuelwood				
Medicine				
Phane worm				
Marula fruit				
Mosata flesh				
Other food				
Other product				

KYT organisation

If the informant is a woman:

Are you a member of KyT?	

If you are a member:	**Yes/No**
Have you received a loan from KyT?	
Are your loan repayments overdue?	
Have you participated in any educational classes through KyT?	

If you are not a member:	**Yes/No**
Have you ever been a member before?	
Have you ever considered becoming a member?	

How many members of KYT are there in the household?_____

Do you agree with the following statements?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't know
KyT members have an advantage over non-members.	☐	☐	☐	☐	☐	☐
KYT activities have a negative impact on the environment.	☐	☐	☐	☐	☐	☐
KyT activities takes up a lot of time for women members in the household.	☐	☐	☐	☐	☐	☐
The women in the household should use their time for other things.	☐	☐	☐	☐	☐	☐
KyT contributes substantially to the household economy.	☐	☐	☐	☐	☐	☐
KyT empowers its members.	☐	☐	☐	☐	☐	☐
It is easy to influence the decision-making in KyT as a member.	☐	☐	☐	☐	☐	☐
KyT members benefit from the micro-credit loans.	☐	☐	☐	☐	☐	☐

Thank you again for your time. You have been very helpful in our investigation.

Appendix C: Soil Testing

Nutrient status:

Performing soils tests is a data collection method that results in hard quantitative data. Soil investigations will be performed with the purpose of establishing indicators of the nutrient status of the soil, which will be done in form of the total carbon and nitrogen soil contents. On this basis we can evaluate the C/N ratio and obtain information out about the quantity and quality of the SOM. We will also perform speedier field tests on the soil for other crop nutrients (phosphate, magnesium and whatever else we can measure on-site). This will form the hard data for the investigation on the nutrient status of the soil together with pH measurements. A soil classification will be attempted, in order to understand the possibilities of the soil in terms of nutrient release. The classification will be done according to the American Soil taxonomy system and in this regard the pH measurement will be of use. They will also aid to further deepen the understanding of the soil and to which extend amendments are possible to aid a higher plant nutrient release. Making use of these hard methods in collaboration with obtaining qualitative data is an enormous advantage when aiming at producing applicable results.

The soil tests will be made in the fields of the case study farmers. The amounts of samples will be made in accordance to obtaining statistical correct analysis and they will be taken in the plough-layer of each field and mixed thoroughly, from there a sub-sample will be used for the final test. Measurement of total C and N soil contents will me made available by performing an elementary analysis using a Flash 1112 EA Machine. The lab analyses will be formed back in Denmark.

Soil Water content analysis:

Determining the moisture in the soil will involve collecting soil samples. Gravimetric Method will examine the soil samples. We will take soil sample of approximately 100-200 grams to at least the depth of the root penetration. The sample is then placed in an oven heated to 105°C for 24 hrs with the container covered. After drying, the sample are again weighed and the weight of water is determined as the before and after readings.

Appendix D: Common Transect walk:

Transect walk will be performed with the farmers as PRA on the land use by the case study farms. We are going to identify field distribution, land use, crops, crop status, farm equipments, ownership and water sources. While making the transect walk, we will note information down on a transect map.

Appendix E: Flow Chart Diagrams

A flow chart diagram can be seen as a diagram of decisions. The diagram is attempting to illustrate decisions that people have made and how they are relating to each other (Mikkelsen, 1995). For this field study flow diagrams will be made on two levels, one describing the overall interactions of agricultural constraints and a more detailed one on the nutrient balance on the farm-level. The latter flow diagram will enable us to involve all relevant inputs and outputs when calculating the nutrient budget. Another benefit of the flow diagram as well as for many other PRA methods is that fact that visualisation for the participant enables the person to realise and analyse the knowledge that is being contributed with. As participant have gained a clearer picture of a situation it would be possible to plan and act accordingly to that plan (White & Taket, 1997). The usefulness of this very illustrative method is also obvious for the researcher as (s)he also gains an overall picture of a situation that is often complicated.

As many people as possible from the household under investigation will be encouraged to take part concerning the nutrient balance flow chart where as the agricultural heads of the households of the case studies will be brought together to make the flow diagram of agricultural constraints interaction.

Appendix F: Semi-Structured Interviews & List of Informants

During the first couple of days of our fieldwork we are going to select a number of key informants, some of them are case study farmers, through the questionnaire execution, which can provide us with information on central issues in relation to their perceptions of agriculture as part of their livelihood strategies. Such qualitative interviews will be semi-structured with open-ended questions, which we have prepared in advance, although we may modify our questions at any time. This flexibility allows the conversation with the informant to be directed unobtrusively.
Below is a list of key informants and a draft interview guide

List of Informants

Agricultural Extension officer
Case study farmers (CSF)
Heads of households
Authorities: Chief, Land board member,
Leader of agricultural group

Appendix G: Interview Guide

Soil Nutrients:
Artificial fertilizer application (Mineral fertilizer)
Organic fertilizer application (Kraal Manure/FYM)
Recycling of crop residues
Tillage practice
Use of implements
Draft power

Water conservation management:
Conservation tillage
Irrigations techniques

Pests and Diseases:
Types of pests
Types of diseases
Most severe
Protection
Treatment (fungicides, insecticides etc.)
Agricultural extension service advice

Labour:
Livelihood strategies
Seasonal distribution
Migration
Dreams of the future

Economics
Farm equipment
Storage
Post harvest techniques
Marketing flow
Market access
Access to credits
Share cropping

Land tenure:
Fencing
Land tenure systems
Ownership of agricultural land
Equality in rights
Changes over the years
Problems with ownership
Problems with other farmers/ users of land
Lost land
Control over land

Appendix H: Ranking
We are going to two kinds of rankings. First, we are going to ask the farmers to define what they conceive as the major agricultural constraints and then rank them. Doing this will empower the farmers and may add new information, on possible constraints. Second, we are going to make a ranking according to pests and diseases which will be ranked by a group of case study farmers according to the same principles before.

Appendix I: Seasonal calendar
The seasonal calendar reflecting agricultural activity for last year:

Year Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Planting (crop)										
Preparing fields										
Weeding										
Harvesting										
Non-agri. Activities										

Appendix J: Sketch mapping
Sketch mapping of the household's holding and tenure is one of the methods to be used in the interviews and an important means of recording information. Labeling the areas according to land tenure classifications can turn into a tenure map, which likewise can serve as a communication tool. The farm sketches are chosen from the case study farms in dialog with the farmer. Such a map will

be made on the transect walk to develop our basic understanding of the tenure categories and their location. The maps are made from observations and information collected systematically walking with informants through an area. We will focus on the spatial distribution of farm land, fencing, natural resources, land use and location of water sources using an informant to assist us along the area when doing the transect walk. The map can also show inter-household dynamics, since men and women often have different rights and responsibilities for the land. The maps are going to illustrate

- Organize the household's tenure in land by use of categories
- Existing user rights of common arable fields
- The perceptions of agricultural users
- The potential conflicts and co-operations within between farm user groups and other user of the communal areas.

Furthermore, it can be used for problem identification, analysis and monitoring for opening up discussion between community members in the interview process (Mikkelsen 1995).

Appendix K: Venn diagram

The Venn diagram is used to show the power relations between actors influencing agricultural production. In order to show how the relations are perceived we are going to ask some of the farmers from our case studies (key informants) to draw a Venn diagram. The farmer will place circles for each of the actors involved in agriculture of different sizes and the size of the circle should show the different weight allocated to the actors by the participants. This will provide a diagram of how power relations are perceived by the farmers.