# The effect of land and management aspects on Maize yield

## (Case study in Limpopo valley, Mozambique)

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# The effect of land and management aspects on Maize yield (Case study in Limpopo valley, Mozambique)

By

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*Dedicated to my Mother,*
*Brother and Sister-in-law*

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# Abstract

Maize is the most preferred staple food in Mozambican and demand increases as population grows. Since the arable area is limited, the productivity has to be increased. One of the methods to enhance yield is by minimising the yield gap and yield variability in farmers' fields through identifying specific land and management factors that causes to Maize yield gap at regional level. The aim of this study was to identify the biophysical factors at field level that causes maize yield gaps in Limpopo during the 2002/03 cropping season using Comparative Performance Analysis (CPA). The study was carried out through a field survey; the quantified land use analysis approach was used to carry out the yield gap analysis. Data on land and land use such as regarding soil texture, varieties, land preparation, sowing/planting, thinning, weeding, harvesting actual and expected yield and farmers' perceptions on yield differences and management like application of FYM, chemical fertilizers, application of pesticides were collected through interviews. Significant land and management parameters were selected through descriptive statistics. Tukey's pair-wise comparison was applied to identify significant mean differences for nominal parameters. Stepwise forward linear multiple regressions was applied to select constraints for yield variability and to derive the production model; it explains 57 % of the encountered yield variability. Note that the model excludes farmers' perceptions on reported yield gap causes like drought, pests and diseases. The data on these parameters proved not logical; statistical analysis showed unexpected opposite relationship. A quantitative production function is derived and used to determine the 'mean' and 'best' values for each explanatory parameter; impact estimates by yield constraints and individual contribution to the overall yield gap. The identified yield constraints and their relative contribution to the yield gap are: light texture soil (27%), Plot size (30%), more seeds per plant hill (30%) and no thinning practiced (13%). The production model was then tested using a separate data set of a previous season to check its value. The model proved significant with an adj. $R^2$ of 43% ($p=0.001$). Therefore, the model is fit to estimate and quantify yield constraints across years of maize in the Limpopo valley. These findings feature the fact that farmers operate at a rather low technology level, and are still at the early level of acquiring proper production skills.

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# 1. Introduction

## 1.1 Yield gap of Maize

In our world of ever growing population, pressure on land resources for its uses becomes increasingly demanding. The land for agriculture gets reduce due to increase in number of users. Food production has to be increased per unit area to meet the growing demand of population. In most of the developing countries, researchers in research station and experimental field show the potential yield (yield under optimum management practices) of crops but actual yield is almost always lower. Yield gap is “the difference of actual yields versus yield obtained under optimum management practices, or yield determined by the land-base natural resources” (Bindraban et al., 2000). It is also defined as the difference between research yield levels (experiment station or on-farm research plots) and average farmers' yields in any given location (FAO, 2000). For food security, the yield gap must be minimized through improving the efficiency of the land use systems. The studies on yield gap has been conducted by many scientists around the world (Becker and Johnson, 1999; Casanova et al., 1999; de Bie, 2000; Gaddi et al., 2002; Rugege, 2002; Van Asten et al., 2003) using various crops.

According to de Bie (2000) many actual production situations face yield constraints that cause a considerable gap between actual yields and yield levels possible with improved technology. Bindraban et al. (2000) suggest that actual yield levels are influenced by land-based natural resources and often even stronger, indirectly by socio-economic conditions. Cultivation practices are based on farmer’s knowledge and skills, access to markets, land tenure, etc. These practices may not meet the agronomic requirements needed to realize potential yield levels at prevailing socio-economical conditions. Yield may differ for a multitude of reasons, resulting in sub-optimal use of land resources or even deterioration of the resource base. Causes of differences in yields on-station and on-farm experienced by same crop is generally multiple and complex (Rockstrom and Falkenmark, 2000). Proper agriculture policy formulation and adequate implementation, knowledge on the constraints that limit yields, and adequate institutional support, is required to minimise suffered yield gaps.

“Maize is the major food source for many poor (CIMMYT, 2003). Research on constraints of maize production in the developing world are prioritised globally and by region, including studies on factors that causes poverty and prolongs subsistence farming (CIMMYT, 2002). In world these is presently much concern for food production for its ever growing population, not only for survival but for eradication of hunger and malnutrition (FAO, 1996): "The right of everyone to have access to safe and nutritious food, consistent with the right to adequate food and the fundamental right of everyone to be free from hunger" (FAO, 2001). Although maize is not indigenous to Africa, it is the single most planted cereal on this continent. Particularly in Eastern and Southern Africa, it is the most important staple grain (Asiema, 1994). In spite of the effort to increase the productivity, there is always a yield gap. Scientists who conducted research of yield gap studies on Maize are An, (2000), Barron et al.(2003), Bretel (1997), Girmay (2000), Rockstrom and Falkenmark (2000), Rugege (2002); they reported different aspects that could minimise encountered yield gaps.

In 2002, Mozambique was severely affected by drought in the southern province including Gaza and most crops failed, creating acute food shortages at household level. In spite of the international support, one of the government's emergency drought response included distribution of Maize seeds for the next cropping session (FEWS, 2003). Maize is the most preferred staple food of the people in Mozambique (FAO/WFP, 2003) and it tends to take much of the land for household subsistence. It is also an important income generating crop and where high yields are possible, farmers dedicate significant portions of their arable land to grow maize (INGC, 2003). Maize productivity on farms remains low but the potential to increase yields exists (FAO/WFP, 2003).

## 1.2 Problem Statement

- The farmers of Mozambique depend heavily on the production of Maize for their daily food consumption. When we see the demand and supply of maize for year 2002/03, there is 109 000 tonnes of maize deficit which has to be supplied from abroad. With 36 000 tonnes of maize aid from WFP in the pipeline, there is still 73 000 tonnes to be covered by additional donor contributions (FAO/WFP, 2003)

- The trend analysis from 1981 to 2002 of yield per ha shows improvements from 400 to 800 kg/ha. (Figure 1-1) (FAO, 2003)

- Though the maize yield per unit area is increasing, it is at a lower rate than the area cultivated (INGC, 2003).

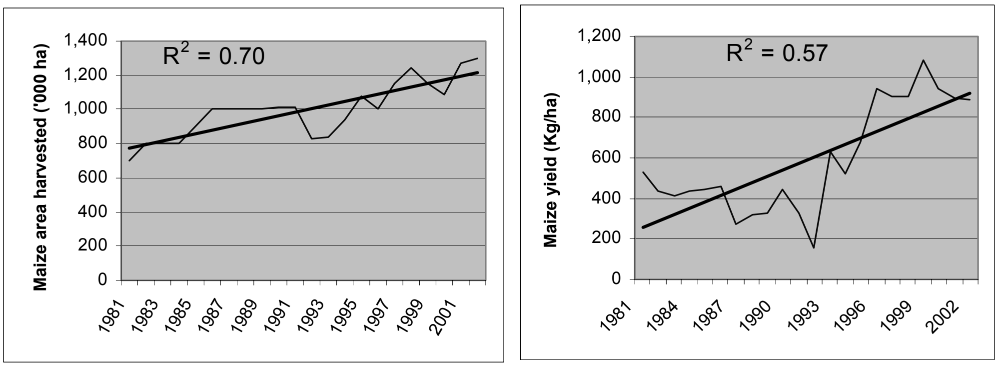


**Figure 1-1: The trend of Maize yields in Mozambique**

- Apart from the consumption of maize as staple food, it is also an income-generating crop for many to support them during lean periods like drought and flood.
- In Gaza province of Mozambique, since 2000, maize yields are slightly declining (Figure-1-2). The yield was calculated from production data of year 1999/2000 to 2002/03. In addition, the yield levels are among the lowest in Mozambique.

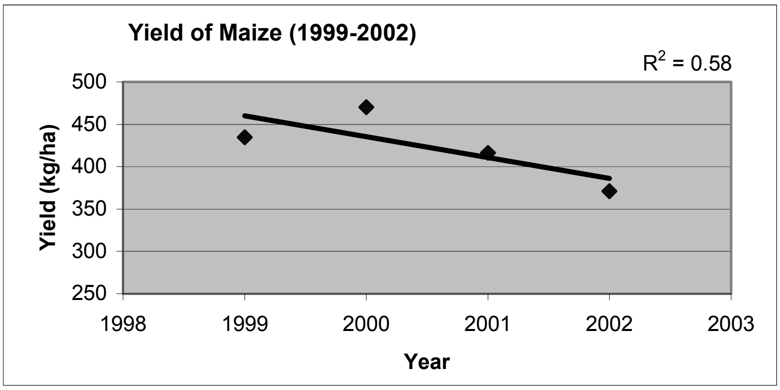


**Figure 1-2: The trend of Maize yields in Gaza Province, Mozambique**

(Note: Produced from the data provided by National Directorate of Agriculture, Maputo)

- Therefore, it is important to identify the biophysical factors that are responsible for the maize yield gap suffered.

## 1.3 Justification

Looking to the importance of Maize production by farmers of Mozambique, and its role to their livelihood and food security, it has to be seriously looked into. It seems that there has been little research carried out to determine the biophysical factors for yield constraints in mentioned Mozambique (location specific) and to recommend the agronomic site specific cultural practices which will minimises the yield gap. "Quantifying the variability in yield and identifying the determining factors are prerequisites to the development of site-specific recommendations and to improve targeting of technologies" (Becker and Johnson, 1999). This is appropriately dealt with by using CPA that explores Yield as a function of Land and Land use (de Bie, 2000). CPA analysis is meant to provide extension agents, fertilizer agents, plant protection centres, planners and decision makers with valuable information about location specific constraints and to develop strategies to improve yields.

## 1.4 Conceptual Base

The conceptual base used is Comparative Performance Analysis (CPA) (de Bie, 2000). Comparative Performance Analysis (CPA) is a quantitative method for yield gap analysis. CPA can identifies major yield constraints and quantifies yield-gap functions by comparing production situations at actual on-farm sites. It assumes that land users operate at various technological levels, i.e. from conservative (traditional) to advanced (experimental), and apply different management packages that make use of indigenous and improved technologies. For successful CPA, the study must focus on a particular land use class and the land use systems surveyed must reflect the entire prevailing range of environmental conditions and all types and levels of technology practiced. CPA considers environmental conditions and management aspects as they occur in a specific study area (de Bie, 2000).

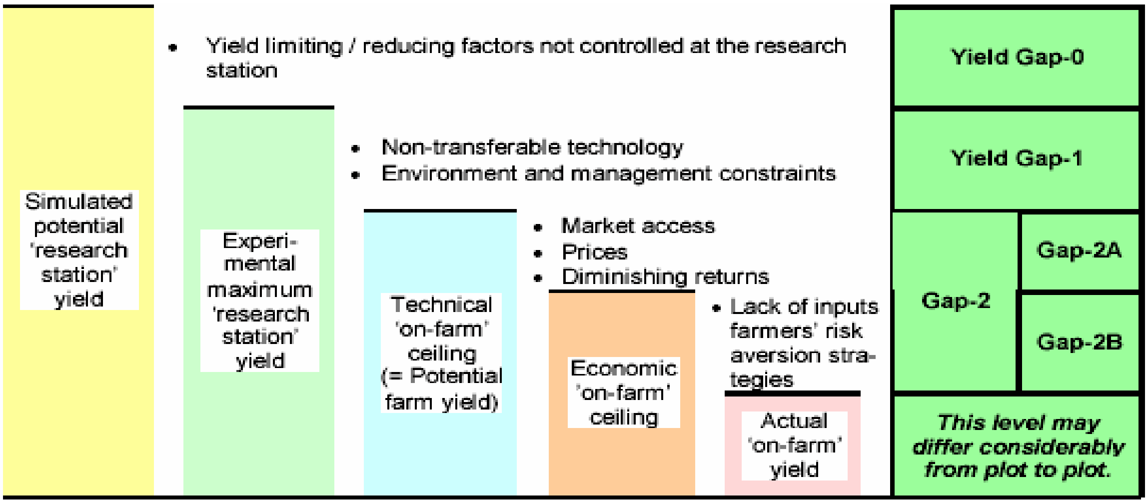


**Figure 1-3: Partial yield gaps and their dominant constraints (de Bie, 2000) modified from Fresco 1984**

## 1.5 General Objective

This study is aimed at identifying land and management constraints that cause yield gaps in maize and to quantify impacts by those yield constraints for maize growth in the Limpopo valley, South-Gaza province, Mozambique, using CPA, Remote Sensing (RS) and Geographical Information System (GIS).

The study sets out to:

- Identify and determine the location specific land and management yield constraints of Maize in the study area
- Quantify for each yield constraint its impact to the overall yield gap with a derived production model
- Test the model fitness with another season dataset of the same study area for the same crop
- Estimate the potential farm yield and actual on-farm yield of maize with the derived production model.

## 1.6 Research Questions

Answering the following questions fulfils the general objective of the study:

- How much is the potential on farm yield of the Maize?
- What is the average actual on farm yield of the Maize in the study area?
- What are the determining biophysical factors for the on-farm yield gap?
- Are there any other site-specific factors that have significant impact on the yield gap of maize?

## 1.7 Hypothesis

- **Yield=f (land, land use)**

**Yield varies with land characteristics** such as soil texture, soil fertility status, and water holding capacity, rainfall; yield is a function of land characteristics. **Yields also varies with the type and level of management** such as, crop variety, seed rate, spacing, irrigation, fertilizer use, field operations like plough before planting, planting, thinning and weeding, harvesting and method used in these operations.

- The production function: Yield = f (land and land use) explains significantly encountered yields for another season data set.

# 2. Methods and Materials

## 2.1 Study Area

Mozambique is located in Southern Africa at the geographic coordinates of 18 15 S, 35 00 E, covering total area about 801,590 $km^2$ (Anonymous, 2003). It is bordering with South Africa and Swaziland to the south, Zimbabwe, Zambia and Malawi to the west, Tanzania to the north. All the eastern part is coastline of 2,470 km (Anonymous, 2003; CIA, 2003). The country is divided in to 10 (Ten) provinces. The focus Gaza province is located between Latitudes $24^{0}\ 30^{/}\ 14^{//}$ and $24^{0}\ 59^{/}\ 44^{//}$ South, and Longitudes $33^{0}\ 05^{/}\ 52^{//}$ and $33^{0}\ 41^{/}\ 32^{//}$ East. The area of the Limpopo River basin is only 19% of the 412,100 sq km. i.e. 79600 sq km (Pereira, 2002). Limpopo basin is located in the southern part of Gaza province (INGC, 2003). The study area is within Latitudes $24^{0}\ 33^{/}\ 52^{//}$ and $24^{0}\ 58^{/}\ 51^{//}$ South and Longitudes $33^{0}\ 06^{/}\ 06^{//}$ and $33^{0}\ 34^{/}28^{//}$ East which, falls within river Limpopo valley covering a total area of 2578 $km^2$ (Figure-2-1). The area includes parts of five districts, Chokwe, Guija, Chibuto, Macia - Bilene, and Xai-Xai.

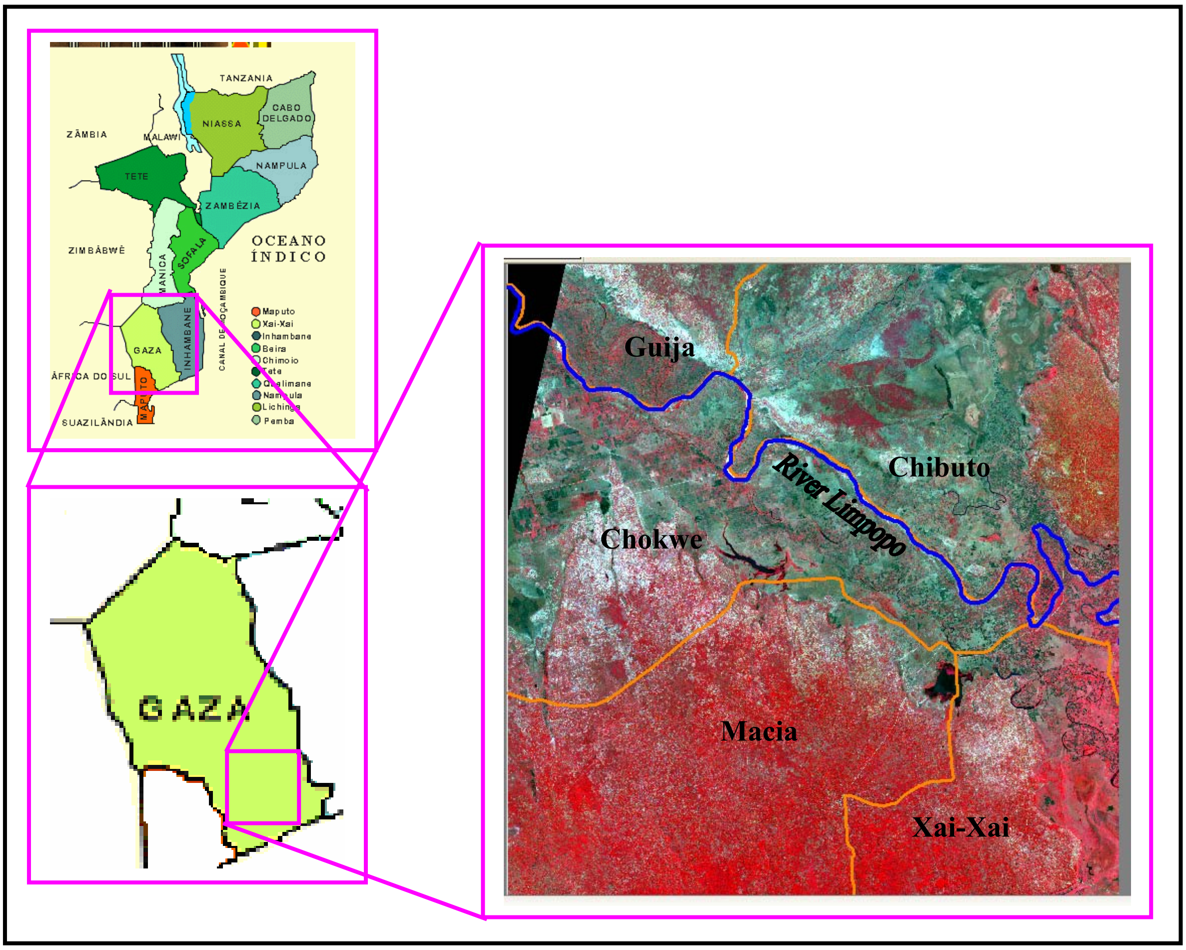


**Figure 2-1: Location of the study area in the country Mozambique**

### 2.1.1 Climate

The climate is semi-arid to sub-humid. The region is prone to frequent drought and uneven rainfall distribution, as it is sandwich between Atlantic and Indian Oceans. Two distinct seasons characterised the region – a dry season approximately from May to October and wet season roughly from November to April (INGC, 2003)

#### Rainfall

In the study area, rain starts from October to March when basin also has the highest temperature, which is called as wet-hot season or summer (INGC, 2003). The average monthly rainfall is from 48-176mm in this season. The dry season starts from April to September, having average monthly rainfall of 19-48 mm in this season. During 2003, June month received exceptional high rainfall of 246mm in the dry season. The wettest months in the basin are January and February and the driest months are July and August. Shown below (Figure-2-2) is the pattern of average monthly rainfall, evaporation and temperature of 1998 to 2002 in the study area.

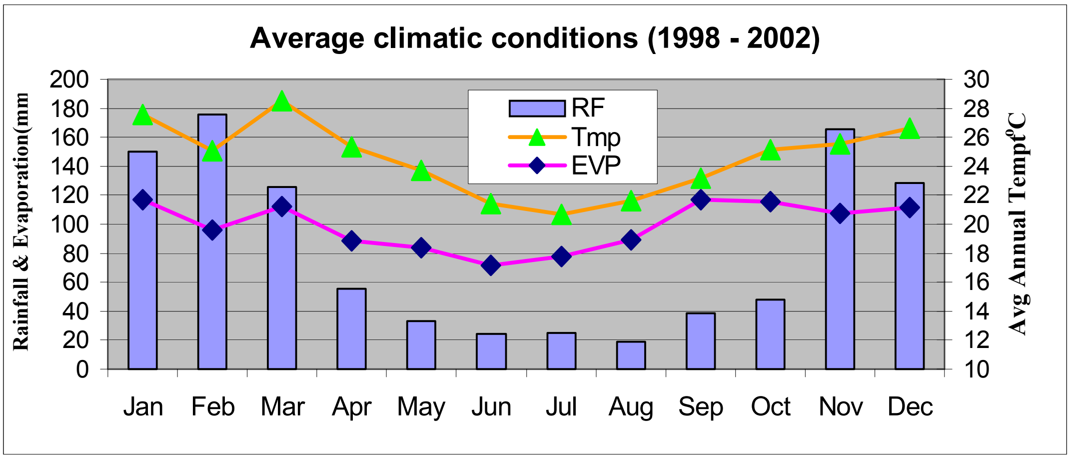


**Figure 2-2: The monthly average rainfall pattern (1998-2002)**

(Note: Produced from data provided by National Institute of Meteorology, Caixa Postal 256-Maputo)

#### Temperature

The highest average temperature is during months of October to March (summer season) and the lowest average temperature is during months of April to September (winter season). In Figure-2-2, shows the average temperature (ºC) for the year 1998-2002 for southern part of Gaza province.

#### Weather stations

Within the study area, there is one weather station located in Chibuto and other is adjacent to study area in Chokwe. The average monthly minimum and maximum temperature (ºC) of 2001 and 2002 is visualized in Figure-2-3. Monthly average minimum temperature ranges from 11-22 (ºC) lowest in

June to July. The maximum average temperature ranges from 25-34 (ºC) highest during the month of December and January.

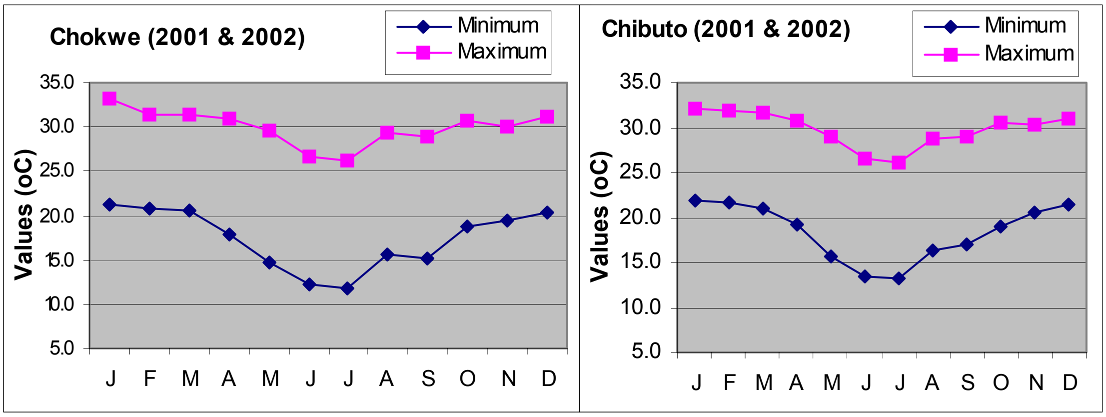


**Figure 2-3: The average minimum and maximum temperature (ºC) of 2001 and 2002**

(Note: Produced from data provided by Weather stations of Chokwe and Chibuto)

### 2.1.2 Soil

The soil of the Basin in Mozambique has deep sands and sandy loam soils with medium to high water holding capacity. A belt of deep clay soils along the flood Plains borders this area. Most of the rest area of Basin has shallow sands and loams with low water holding capacity. Clay soil has typical higher water holding capacity that can create a barrier to water drainage and are likely to remain wet long after a rainfall. Water logging and flooding due to local rainfall is common in such soils. Low water holding capacities are more typical of sandy soils that are unable to hold much water. Loamy soils are the intermediate case; good for agriculture, they hold a fair amount of water without becoming waterlogged (INGC, 2003). Soil map of the study area (Figure 2-4) shows different types of soil classes later grouped in to three texture classes.

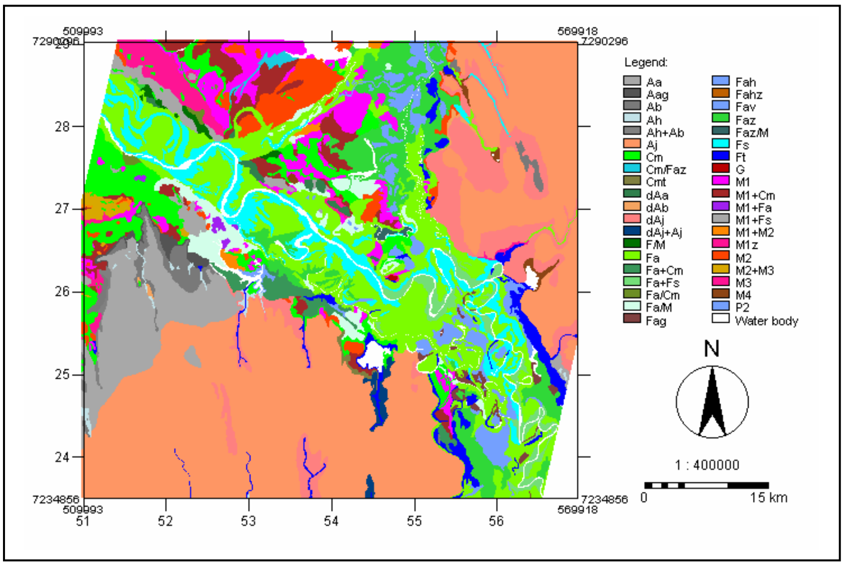


**Figure 2-4: Soil map of study area.**

### 2.1.3 Land cover and land use

Land cover of the study area is very heterogeneous in nature, with no clear boundary of different cover types. It has mostly rain fed cropped area with annual and perennial crops. Other cover types are grassland, Shrub land, dry land crops and pasture, cropland/grassland mosaic, cropland/woodland mosaic and settlements (INGC, 2003).

The land use is mostly agriculture. Some parts get irrigation from the irrigation reservoirs and some farmers have their own water pumps for irrigation. There are two types of livestock breeding-traditional and improved farms, which are restricted to smaller areas (Pereira, 2002). The crops grown are mostly Maize irrespective of landform, soil type, and water availability, other land use such as Cashew gardens, except in small patches of shrub land, grassland, pastures and swampy areas. Other crops like beans, tuber crops like cassava and sweet potato are grown in and around the Maize field as inter crop or along the boundary of maize plot (only in some localities). Vegetables like tomato, pumpkins, cabbage, and cauliflower are grown in the irrigated flood plain or by the farmers who owns water pumps. The cash crops like cashew are seen growing mostly on the highlands with poor management practices.

### 2.1.4 Area cultivated and production

The cultivated area, production and income (Tons/ha) of Maize of 5 out of 11 districts of Gaza province were shown as Table-2-1 for year 1999/2000 to 2001/2002

**Table 2-1: Cultivated area, production and income (Tons/ha) of Maize**

| Districts | 1999/2000 | | | 2000/01 | | | 2001/02 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Area (Ha) | Production (Tons) | Income (T/ha) | Area (Ha) | Production (Tons) | Income (T/ha) | Area (Ha) | Production (Tons) | Income (T/ha) |
| **Xai-Xai** | 23913 | 11956 | 0.50 | 28053 | 11221 | 0.40 | 27476 | 9617 | 0.35 |
| **Bilene-Macia** | 18869 | 13439 | 0.71 | 21109 | 8444 | 0.40 | 19689 | 6891 | 0.35 |
| **Chibuto** | 18119 | 10061 | 0.56 | 20180 | 10090 | 0.50 | 15604 | 7022 | 0.45 |
| **Chokwe** | 15406 | 395 | 0.03 | 18311 | 9339 | 0.51 | 17247 | 7761 | 0.45 |
| **Guija** | 6508 | 3740 | 0.57 | 7881 | 5517 | 0.70 | 6041 | 2416 | 0.40 |

(Note: data source from the National Directorate of Agriculture-Maputo)

### 2.1.5 Population

About 1.06 million population lives in the Gaza province (INE, 1999) out of which about 80% are agriculture oriented (INGC, 2003). Table 2-2 shows the percentage of the total population figure reflected.

**Table 2-2: Percentage distribution of population per sex per district, Gaza Province, 1997**

| District | Total | Men | Women |
|---|---|---|---|
| **Gaza N (000)** | **1,062.40** | **456.9** | **605.5** |
| Bilene Macia | 12.5 | 12.4 | 12.6 |
| Chibuto | 15.5 | 15.1 | 15.8 |
| Chókwè | 16.3 | 16.3 | 16.3 |
| Guijá | 5.4 | 5.4 | 5.4 |
| Xai-Xai | 15.6 | 15.6 | 15.6 |

Source: (INE, 1999)

## 2.2 Research Methods

The preliminary study area was identified before fieldwork after a visual interpretation of an Aster Image of 14 June 2003, and a literature review. The overall research method is shown in Figure 2-5 as a flow chart. The aim of this study was to develop a model for assessing land and management factors with explanatory analytical statistics for the entire study area through CPA (de Bie, 2000) using mobile GIS.

### 2.2.1 Mobile GIS as a Tool

Mobile GIS is a growing technology for spatial field data collection. It integrates three essential components, Global Positioning System (GPS), rugged handheld computers, and GIS software. The Compaq-iPAQ pocket PC running at 200MHz under MS-Windows-CE (v. 3.09) is able to run Arc-Pad (v.6.0) and to connect to a GPS. The pocket PC has backlight-features so that in bright sun the screen is still perfectly readable. The user can save the GPS-track log (as points in lat-long), or use the GPS to prepare shape files (point, line, or polygon features) in the projection system of loaded maps. The software also allows to prepare forms (questionnaires), and to draw points, lines, or polygons directly by hand on the screen. The exact acreage, as well as other dimensions such as perimeter length of the field can be calculated by using the resulting coordinates and the software. The "GPS-iPaq-Arc-Pad" combination comprises a compact but complete set-up of digital survey equipment that can be employed in the field by car or on foot (de Bie, 2002).

Most problems with the system relate to knowledge on projection systems, to the need to prepare *.prj files containing projection information, and to proper use of datum settings. Once the GPS is connected, the position accuracy on loaded maps will be within 10m pending on proper GPS reception.

With the advent of low-cost, easy to use and field-ready computing devices, this is now more cost effective than ever before (Spencer, 2002). Therefore, this improved GIS technology can be applied to improve the quality and efficiency of required geo-spatial information production with special emphasis on capturing plot sizes. Hence, the mobile GIS techniques can be used for spatial data collection in agricultural surveys in yield gap analysis studies (de Bie, 2002).

Dr. Kees de Bie, NRS department, ITC, conducted a two-day workshop on Mobile-GIS for students. Installation of Microsoft ActiveSyn and ArcPad 6.0 in the iPAQ, connection and communication of GPS with iPAQ, digitising as poly line, polygon, attribute table creation, and go to function were taught which were very useful in the field work. Image shift correction, conversions of Image to Mr SID file, creation of projection file were also taught. The digital copy of satellite images, topographic map, soil map were converted into Mr. SID files and downloaded in the iPAQ that was used in the field for digitising sample plots.

For the purpose of fieldwork and visual classification, hard copy images were needed. The colour composites were made from the data of Aster Image 2003, using 3, 2, 1 band in RGB transformation. This is for improved visual interpretation of land cover. Hard copy of Topographic and soil maps was also printed out for the fieldwork.

### 2.2.2 Research Materials

The research materials, which were used in this study, are listed in Table 2-3.

**Table 2-3: Materials used for the study**

| Materials | Used for |
|---|---|
| Topographic maps: 1:250,000 | Navigation to reach on the selected site of sampling |
| Aster Image of $14^{th}$ June 2003 (15 m resolution) | Identifying the sampling areas in the study area |
| GPS-iPAQ set and their accessories | Positioning of the sample fields and digitizing of field boundaries. |
| Soil auger, pH paper | Taking top (0-20cm) soil sample for texture & pH testing |

### 2.2.3 Software

Most of the image processing and the GIS operations during this research were carried out using ILWIS version 3.1. Some specific image processing operations was done using Erdas Imagine version 8.6, ArcMap 8.0. ArcPad 6.0 was extensively used in the field for digitizing plot boundaries that were saved as shape files. Other software used this study, is listed in Table 2-4.

**Table 2-4: Software used**

| Software group | Trade names |
|---|---|
| Spreadsheet | MS Excel |
| Statistical | MINITAB, SYSTAT 7.0, SPSS |
| Word processing | MS Word; Visio; Microsoft Power Point, EndNote 5.0 |

### 2.2.4 Flow chart of research method

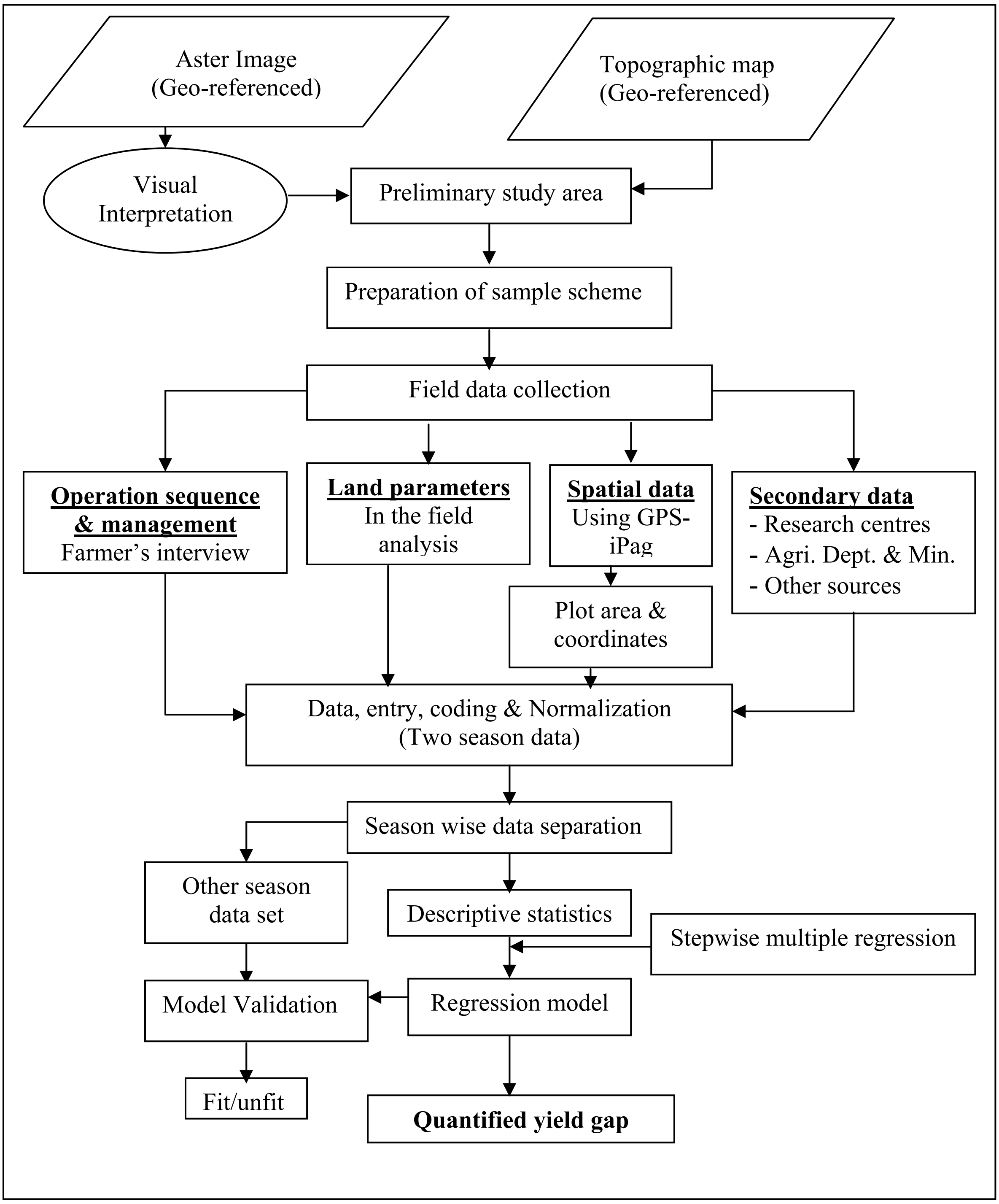


**Figure 2-5: Flow diagram of research method for biophysical yield gap analysis**

### 2.2.5 Data collection

The scheduled fieldwork was 6weeks; it started on 16 September and lasted till 26 October 2003. After reaching the area of interest, we had two days of reconnaissance survey to get overall idea of the study area of approximately 65km x 70km. In general, the area was very heterogeneous in nature. Predominantly, agriculture practices are subsistent in nature (Albano, 2002). Maize is cultivated almost everywhere including within the Cashew gardens as intercrop except for some place like swampy low-laying areas, which are prone to flood hazards.

#### Land use data collection

The land use data collection started on 22 September 2003 and at the end of fieldwork, data of 98 samples (two seasons) from 30 villages under 8 administrative posts within 5 districts were collected. A checklist (Appendix I) was used to collect the data. Through interviews, primary data on operation sequence and management practices were collected. Land preparation before planting, power used in each operations, planting, methods of planting, number of seeds used, spacing maintained, varieties, thinning & weeding, fertilizer application, pest and disease control, date of harvesting, actual and expected yields and farmers' perceptions of causing the yield differences were obtained through farmers' interviews (Figure-2-6a). Villages were selected randomly. In each village, farmers were interviewed depending on their availability and whether they grew Maize in any of the two season of year 2002/2003 by taking them to their own respective fields.

**Figure 2-6: (a) Interviewing farmer through interpreter Mr. Samuel (b) Analysing soil texture by feel method**

The primary data on land parameters like soil texture and pH were taken in farmers' field (Figure-2-6b). Top soil (0-20cm) textures were determined in the field by feel method (Thien, 1979), pH test were done at the same time by pH paper provided by ITC; 10gms of soil sample was mixed with about 50ml of pre pH tested water, mixed thoroughly for one minute and then pH paper was put in the water for about one minute.

#### Spatial field data

A handheld computer and a GPS (Figure-2-7a) were used to digitise the boundary of sample plots. The operator walked along the actual field boundary with the GPS-iPaq system (Figure-2-7b), which recorded the field polygon coordinates. The obtained coordinates were downloaded to a main computer for further analysis. The GPS data collection interval was set to record a point every one or two seconds. The operator used stream mode to make polygons, while walking mapping progress was followed on the screen to ensure no points were missed and that collected data ended at the starting point of the exercise.


**Figure 2-7: (a) Mobile GIS set with digitized plots in zoom view (b) Digitizing the field boundary**

## Secondary data collection

Maize yields at the research centre and of trials at different locations were obtained from the Research station, Chowke. These data were collected for reference in this study. Yield data of maize by district were collected form the Ministry of Agriculture, Maputo covering the last 5 years.

## Sampling method

A random clustered sampling method was used to obtain land and management datasets for the year 2002/03. Randomisation was done to obtain variability, clustering was done to increased the number and effectiveness of sampling within the given time (Thompson, 1991). Figure-2-8 shows the study area and positions of sampled sites on Aster image of 14 June 2003.

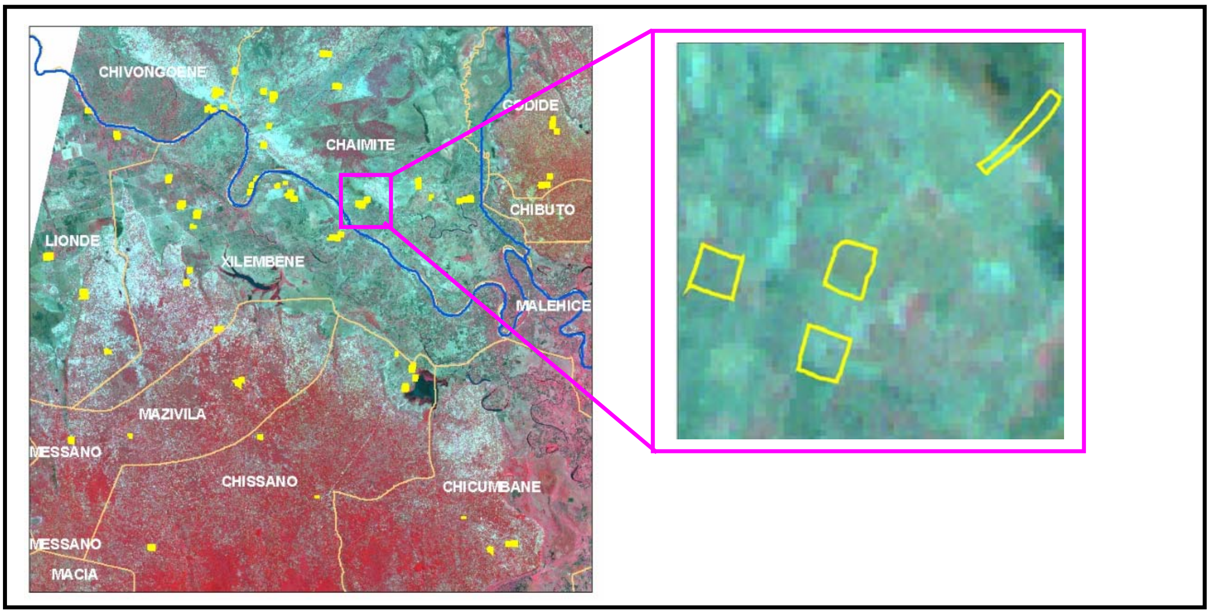


**Figure 2-8: Aster image of 14 June 2003 with administrative post boundaries and sample plots**

### 2.2.6 Data entry and normalization

To analyse the data efficiently, data entry and normalization was carried out using MS Excel. Data were coded and a codebook was prepared as reference during data analysis (Appendix II). Parameters and parameter values were defined in the codebook. Coded tables were prepared as spreadsheet in Excel (Appendix III). Units of measurements were standardized into standard measurement units. Nominal data were transformed into ratio data by normalization to facilitate statistical analysis and data visualization; Table 2-5 shows a data normalization example. Nominal parameters were transformed to ratio data containing only "1" or "0" (Yes or No), so that they can be used for regression analysis.

**Table 2-5: Normalization of data**

| **Raw data** | | | **Normalized data** | | | | |
|---|---|---|---|---|---|---|---|
| **Sample ID** | **Soil texture** | **Yield** | **Sample ID** | **Light (L)** | **Medium (M)** | **Heavy (H)** | **Yield** |
| 1 | Sand (light) | 500 | 1 | 1 | 0 | 0 | 500 |
| 2 | Loam (medium) | 800 | 2 | 0 | 1 | 0 | 800 |
| 3 | Clay (heavy) | 1600 | 3 | 0 | 0 | 1 | 1600 |

### 2.2.7 Descriptive statistics

Descriptive statistics including Tukey's test were generated to screen which land and management parameters are significantly related with maize productivity. SYSTAT 7.0, MINITAB Release 13 and SPSS software were used for this purpose. The statistical relationships were displayed as box plots and scatter plots.

### 2.2.8 Multiple regression

The mean response of the production function;

**Yield = f (land, land use) is:**

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots\ldots\ldots + \beta_n x_n$$

Where, $y$ is the maize yield (kg/ha) explained by the land and land use parameters $x_1$, $x_2$ and $x_n$; and $\beta_1$, $\beta_2$ and $\beta_n$ are the regression coefficients.

The stepwise multiple linear regression method was used to model yield. To avoid the danger that too many parameters are included, considering the number of included cases, the stepwise forward method was used (de Bie, 2000). Final regression equation was derived through researcher' controlled 'trial and error' approach to quantify the impact of yield constraints on yield.

# 3. Descriptive Statistics

Yields were reported "on the cob" as the farmers after harvest do not immediately separate the cobs from the grain. The quantities they measure were in bags of 50 and 80 kg or in bullock carts. The quantity of carts in bags or in kg was taken according to the farmers' knowledge and experience during the interview.

The 71 yield data obtained were subjected to descriptive statistics to test for normality. To fulfil the assumptions of regression analysis the dependent variable must be normal (McCabe, 2002). The yield data were plotted in a probability curve; they were as observed as not normal since the pattern does not follow a straight line (Figure-3-1). This was confirmed through the Anderson-Darling, Ryan-Joiner and Kolmogorov-Smirnov normality tests. After a natural log transformation, **Ln (yield)** then became normal for the Anderson-Darling normality test; five "0" yields were however omitted. (Figure-3-2)

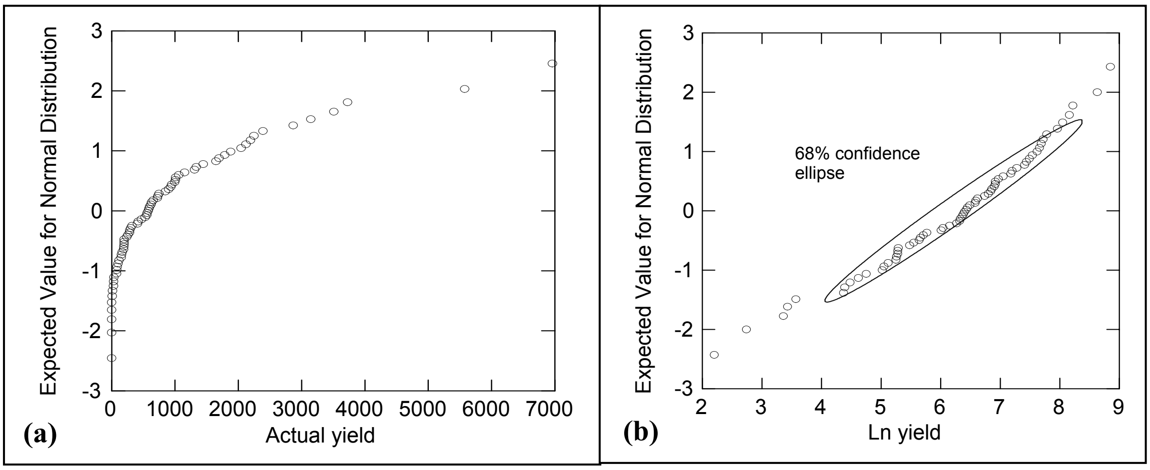


**Figure 3-1: (a) Probability plot of yield before log transferring (b) after log transferring in SYSTAT 7**

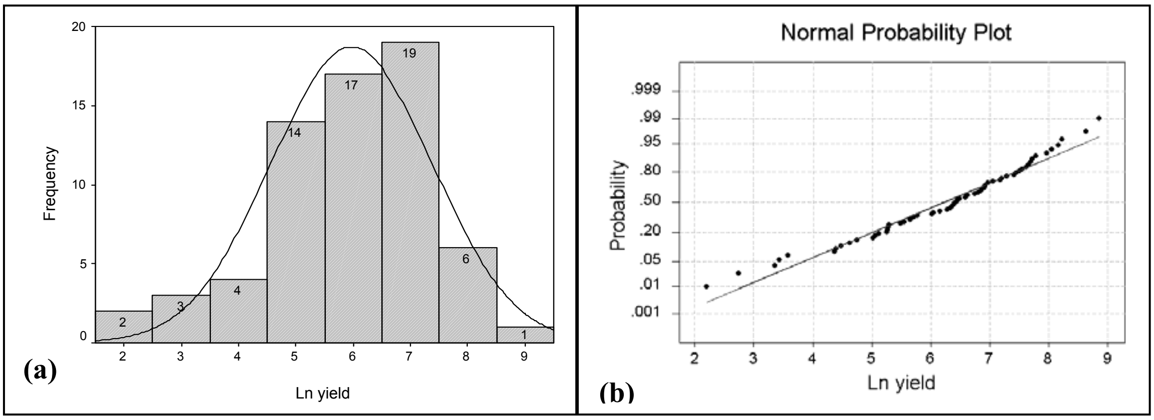


**Figure 3-2: (a) Histogram with normal curve (b) normal fitted plot of Ln yield**

## 3.1 Varieties grown

Within the study area, most farmers used a local (Lo) variety (60X) or Matuba (Ma), an improved variety (3X) or Nhankuweni (Na), according to the farmers a drought resistant variety (3X). Figure-3-3 shows the yield variability by variety grown. The effect of varieties on the natural log of yield was not significant (ANOVA: p>0.05) and the count of varieties used was biased towards local.

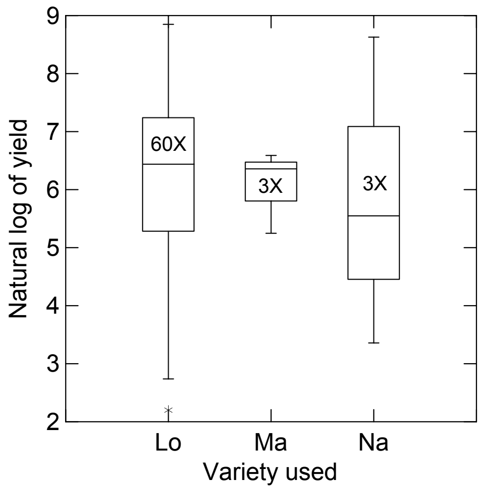


**Figure 3-3: The varieties grown and Ln yield**

## 3.2 Land Characterstics

### Soil texture

There are 10 different soil texture classes identified by the feel method (Thien, 1979). These classes were merged into 3 classes; Light (L), Medium (M) and Heavy (H) according to its capacity to hold water (Whiting, 2002). Soil texture versus Ln yield is shown in Figure-3-4. It shows that Ln yield is significantly effected by soil texture (ANOVA analysis: p<0.05).

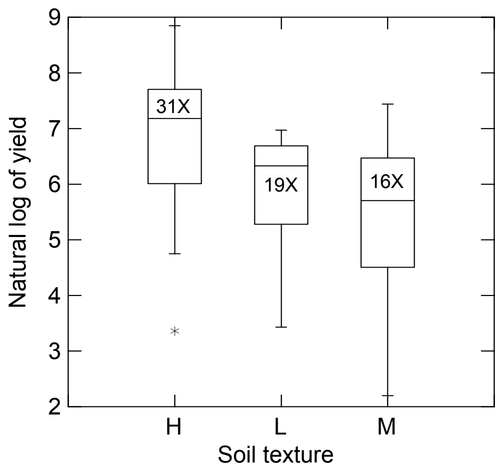


**Figure 3-4: The soil texture and Ln yield**

Tukey's pair wise comparison (Table-3-1) shows that only the heavy (h) soil texture is significantly different from light and medium texture.  There is no significant different in natural Ln yield between low and medium. The location and average reported yields by texture class are shown in Figure 3-5

**Table 3-1: Tukey's pair wise comparisons between soil texture and Ln yield**

| | l | m |
|---|---|---|
| m | -0.653<br>1.475 | |
| h | -1.867<br>-0.040 | -2.329<br>-0.399 |

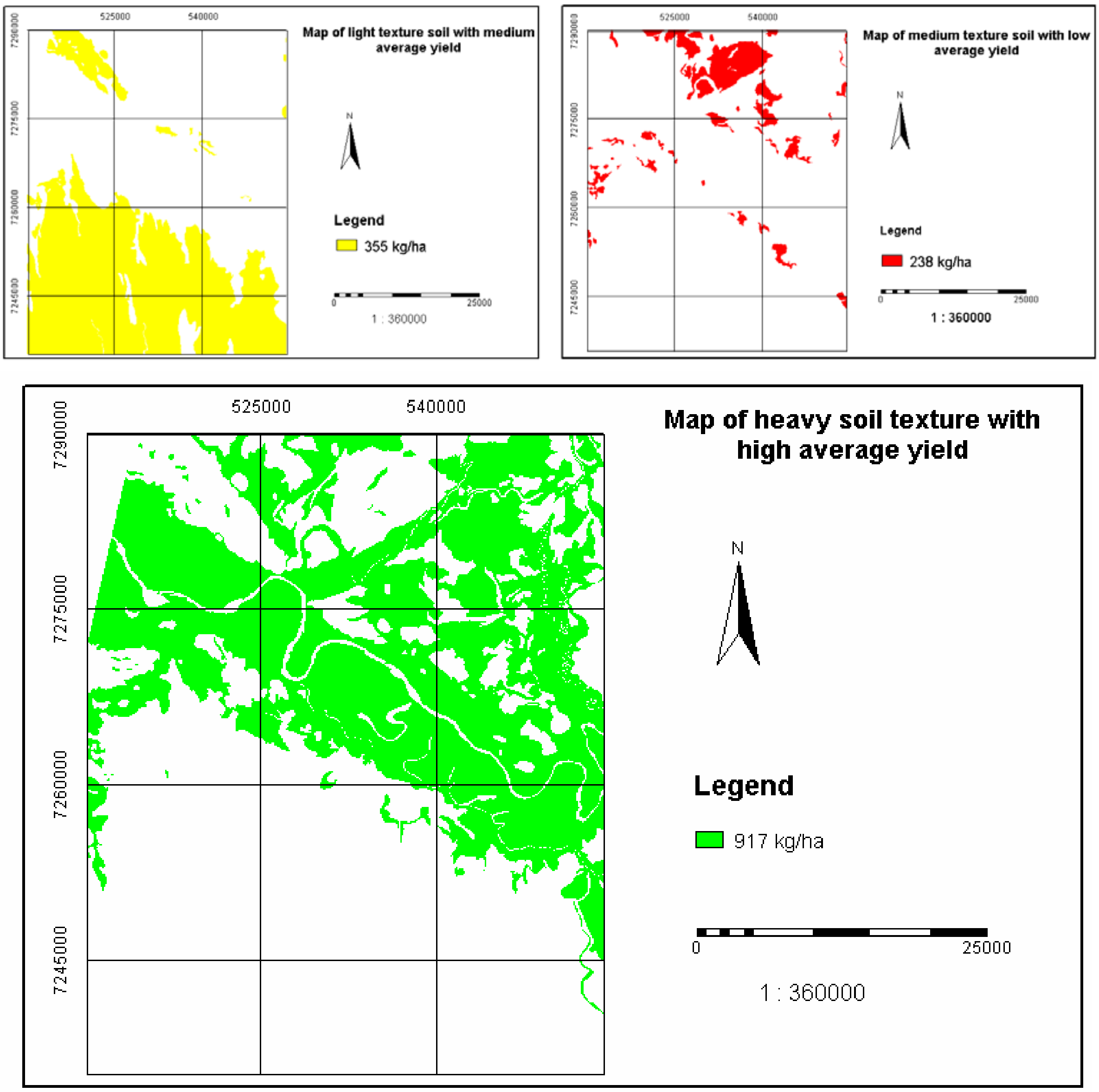


**Figure 3-5: Maps of three major soil textures having different average yields.**

## Soil pH

The soil pH in the study area ranges from 5 to 7. Figure 3-6 shows that there is no relation with the observed soil pH from the field with Ln yield ($p>0.05$ and $R^2 = 0\%$ in simple regression).

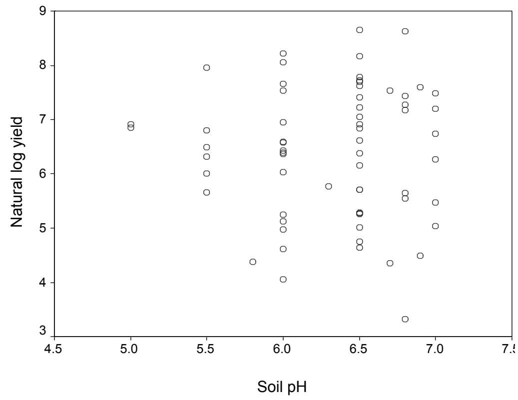


**Figure 3-6: Soil pH and Ln yield**

## Plot size cultivated in hectare (ha)

As the area increases the natural log of yield tends to decrease (Figure-3-7). It shows that plot size has significant impact on natural log yield. In simple regression; $p<0.05$ and $R^2 = 19\%$. In the study area, agriculture practice is labour intensive. Therefore, the finding is probably due to poor management in larger area.

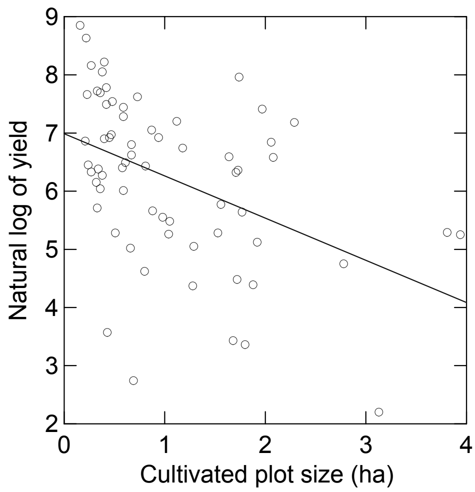


**Figure 3-7: Plot size in hectare and Ln yield**

## Located in irrigation scheme

13 fields were located within the irrigation scheme; almost all functions of the scheme were stopped due to the flood of 2000. Figure-3-8 shows for those sites higher Ln yields but ANOVA analysis indicates a non-significant effect ($p>0.05$).

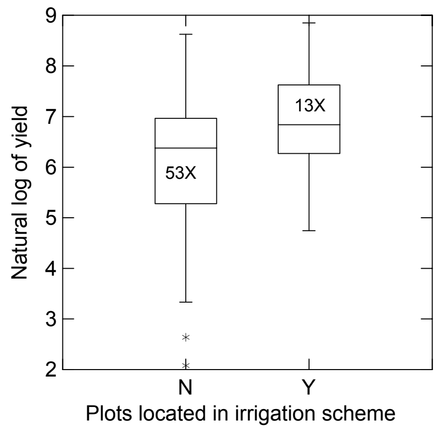


**Figure 3-8: The fields located in the irrigation scheme and Ln yield**

### Fields flooded during 2000 flood

23 samples sites are on upland and 43 on low land (flooded in 2000). Figure-3-9 shows that the average yield in the low land is a bit higher and their variability. The ANOVA analysis showed no significant differences.

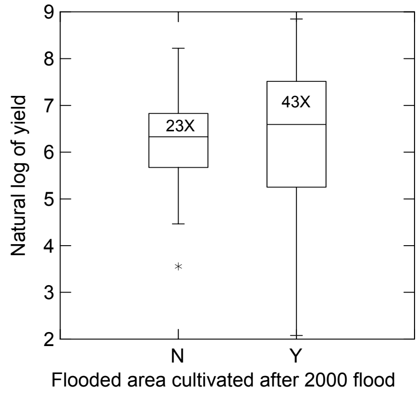


**Figure 3-9: The fields flooded and Ln yield**

## 3.3 Operation sequence

Cultivated Maize is mostly twice a year: April to September (winter season) and October to March (summer season). All major operations carried out and their time period for summer season maize are summarised in Figure-3-10. The figure includes data of all surveyed plots on which summer season maize was grown.

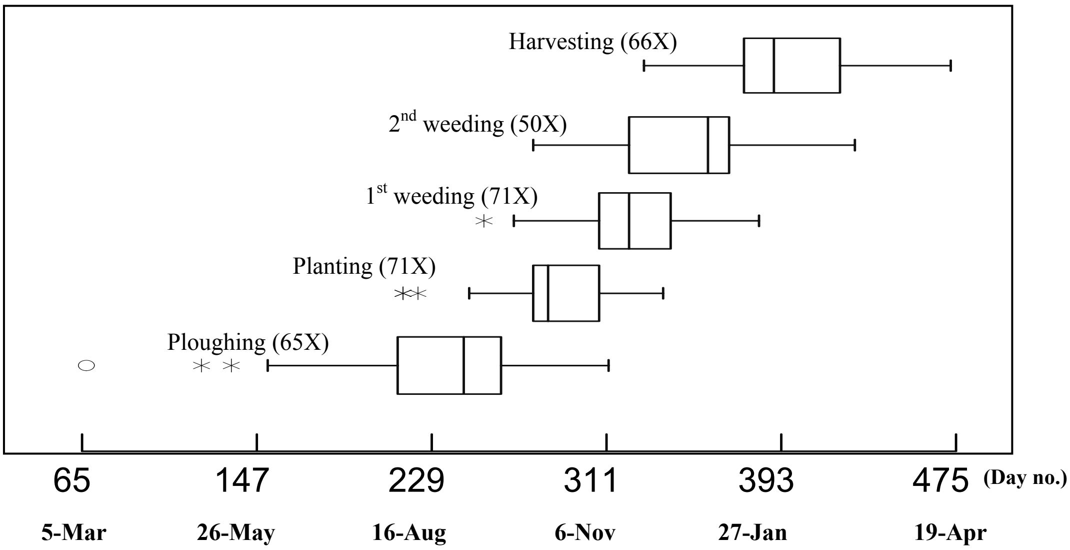


**Figure 3-10: Major Maize management practices in Limpopo valley, 2002/2003**

### Ploughing versus Ln yield

Out of 66, 60 farmers ploughed before planting; 6 farmers carried out planting at the same time as ploughing. Figure-3-11 shows that their mean yield does not vary significantly (ANOVA, p>0.05)

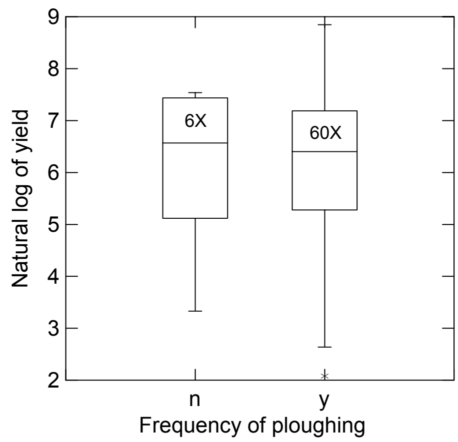


**Figure 3-11: Frequency of ploughing and Ln yield**

## Timing of Ploughing

There is no relation between dates of ploughing after 1January 2002 and Ln yield (Figure-3-12). Simple linear regression analysis has $R^2$ =0.00 and p>0.05.

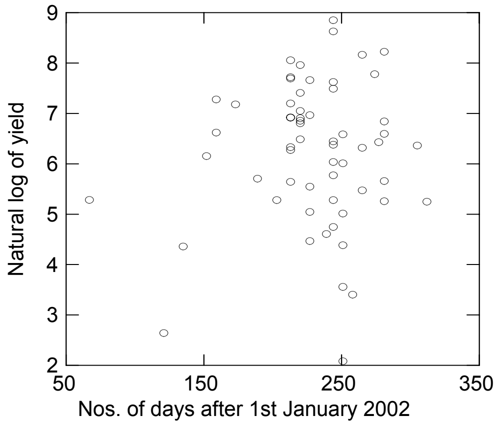


**Figure 3-12: Ploughing after 1January 2002 and Ln yield**

## Method of ploughing

The power source used for ploughing is either animal or manual. Very few farmers used tractors; they are merged with animal source. Figure-3-13 shows that Ln yield is higher in case of animal power than manual powers, however, ANOVA analysis shows an insignificant impact with p>0.05.

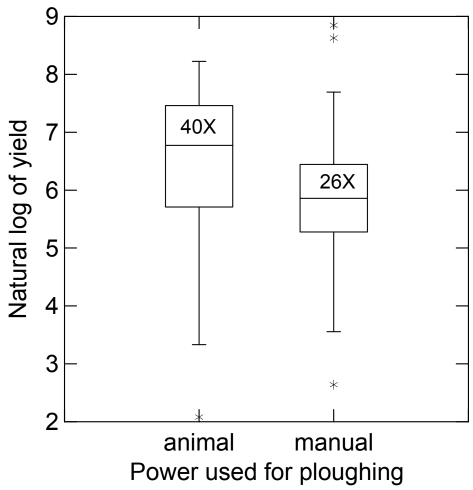


**Figure 3-13: Method of ploughing and Ln yield**

## Date of planting

The date of planting is converted into number of days after first of January 2002.Figure-3-14 shows that there is no relation between date of planting and Ln yield (Simple linear regression analysis with $R^2$ =0.01 and p>0.05).

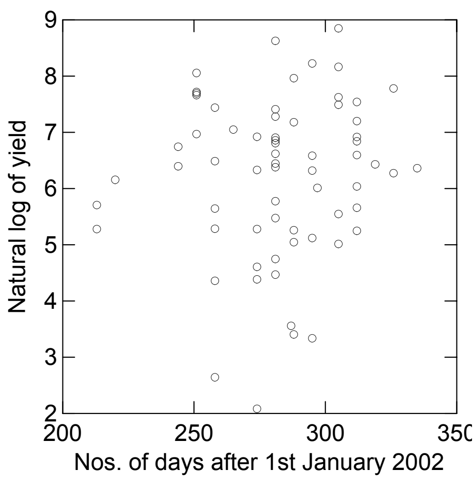


**Figure 3-14: Date of planting and Ln yield**

## Power source for planting

Animal and manual are the most common sources of power for planting. Figure-3-15 shows that use of animal has higher average Ln yields than manual. ANOVA analysis shows insignificant different in Ln yield at $p>0.05$ with $R^2 = 0.035$.

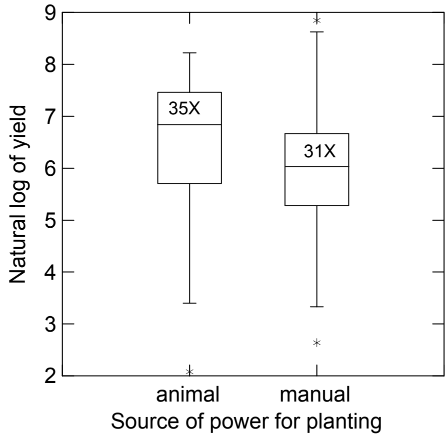


**Figure 3-15: Planting power used and Ln yield**

## Method of planting

Methods practiced for planting are hill and line planting. Hill planting is mostly associated with manual digging the soil and placing the seeds without particular direction, while line planting is mostly associated with animal ploughing, placing the seeds in the furrow as the animal drags the plough. The average Ln yield is higher for line planting (Figure-3-16) than for hill planting. ANOVA; $p>0.05$ with $R^2 = 0.01$.

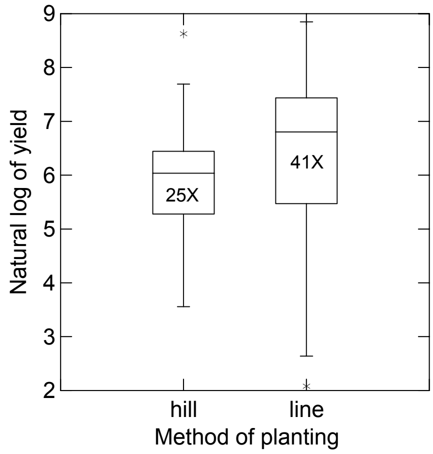


**Figure 3-16: Planting method and Ln yield**

## Number of seeds per hill

The farmers usually have a traditional habit of planting 2-4 seeds or sometime more than 4 (up to 6) in a plant hill. After thinning, they usually maintain 2-4 plants. In Figure-3-17, it is clear that 2-3 plants per hill have higher Ln yield than four or more plants. It shows that Ln yield is significantly different (Simple regression analysis: $p<0.05$), $R^2 = 0.23$). T-test result is shows in (Table-3-2). As the number of plants per hill increases, they have to compete for available moisture, nutrient and light for photosynthesis, which are main elements for dry matter accumulation; impact of water stress may also be severe.

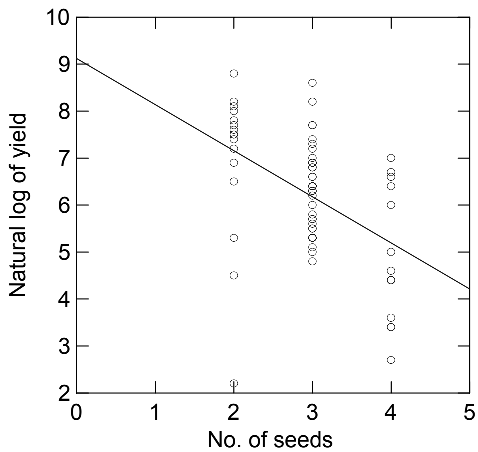


**Figure 3-17: Number of seeds per hill and Ln yield**

**Table 3-2: T-test result with coefficient and Ln yield**

| Predictor | Coefficient | T-value | Prob |
|---|---|---|---|
| Constant | 9.0959 | 12.85 | 0.000 |
| Nosh | -0.9731 | -4.16 | 0.000 |

## Plant hills per hectare

Farmers of the study area usually plant ranging from 40cm to 150cm spacing. The plant hill density (Figure-3-18) does not show any impact on Ln yield. Simple linear regression is insignificant ($p>0.05$ and $R^2 =0.00$). This suggests to have more plant hills with less seeds each than practicing reverse options.

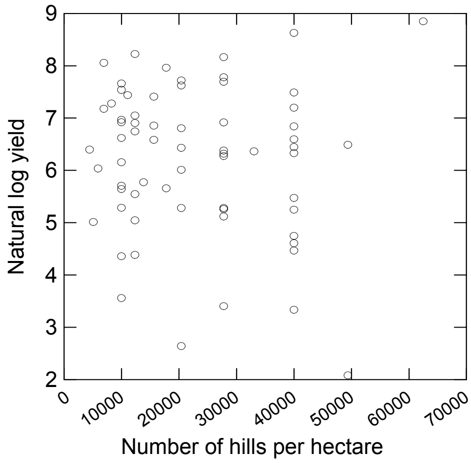


**Figure 3-18: Plant hill density and Ln yield**

## Thinning

Most farmers practiced thinning of seeds planted after germination. The practice of thinning done shows higher Ln yields than when not had done (Figure-3.19). Thinning has a significant impact on Ln yield (ANOVA: $p<0.05$ and $R^2 =0.09$). Thinning is the process of taking out extra number of plant from the field. This practice facilitates remaining plants to have proper spacing and less competition for available soil water, nutrients and sunlight for their growth and accumulation of dry matter.

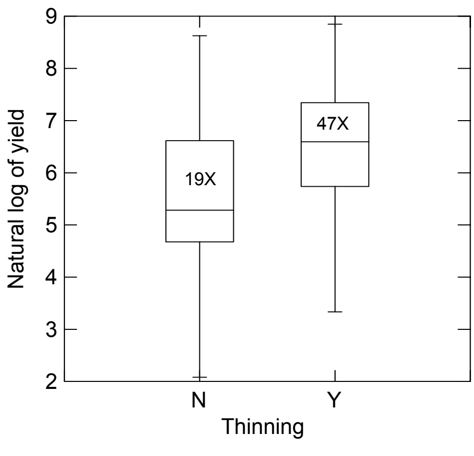


**Figure 3-19: Thinning and Ln yield**

## Frequency of weeding

Figure-3-20 shows that weeding twice after planting has higher Ln yields (ANOVA: $p<0.05$ and $R^2 = 0.07$). Weeding twice instead of only once keeps the field free from weeds that cause competition for growth and development of maize at the time of tasseling and silking. Weed could cause up to 15% yield loss by competing with maize (Wokabi, 1994).

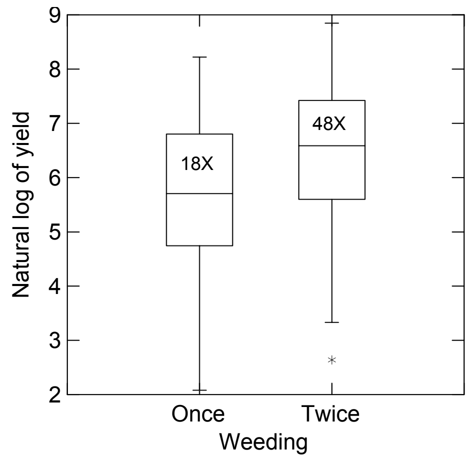


**Figure 3-20: Number of weeding and Ln yield**

## First weeding after planting

Some farmer started the first weeding as early as 14 and some started 99 days after planting. Figure 3-21 shows the first weeding in days after planting versus Ln yield. No significant was found.

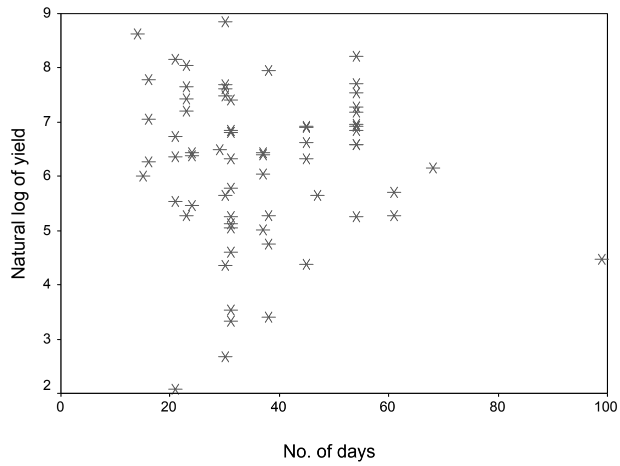


**Figure 3-21: First weeding (No. of days) after planting and Ln yield**

## Second weeding after planting

Out of 71 interviews, only 50 farmers carry out second weeding. This operation was done at different time after planting. Some farmer started on 37 days and some on 99 days but one farmer has done very late on 113 days after planting. Figure 3-22 shows second weeding versus Ln yield. Simple regression shows there is no significant impact on Ln yield ($p>0.05$ and $R^2 = 0.00$).

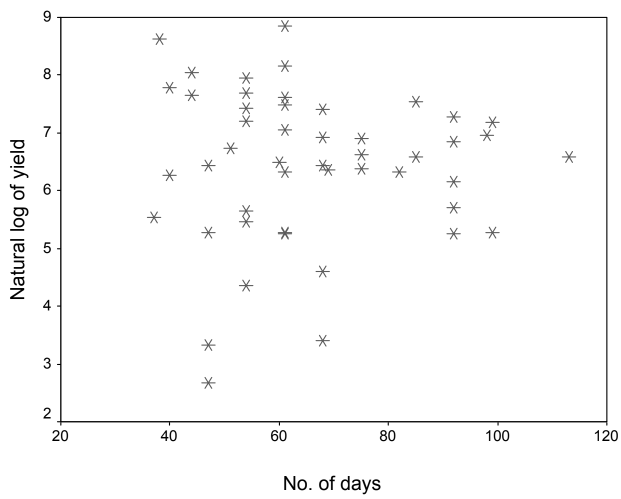


**Figure 3-22: Second weeding (No. of days after planting) and Ln yield**

### Harvesting

The date of harvesting is converted into number of days after first of January 2002 in cases. Figure-3-23 shows that there is no relation between date of harvesting and Ln yield. Simple linear regression analysis with $R^2 = 0.02$ and $p > 0.05$.

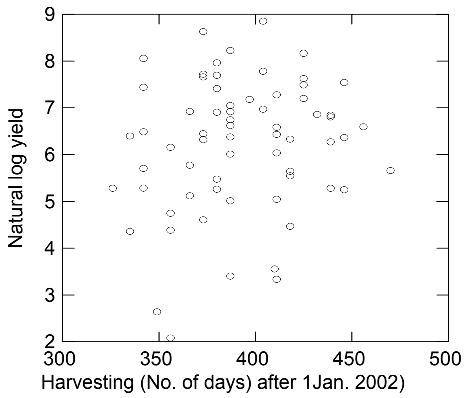


**Figure 3-23: Harvesting date and Ln yield**

### Length of crop growing period (LGP)

The length of crop growing period (LGP) does show any relation with Ln yield (Figure-3-24). Simple linear regression analysis shows insignificant effect on Ln yield with ad. $R^2 = 0.00$ and $p > 0.05$.

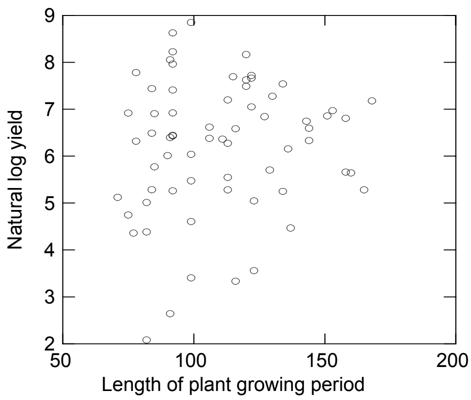


**Figure 3-24: Length of crop growing period and Ln yield**

## 3.4 Farmers' perception on yield gap

Almost all farmers reported a yield gap due to drought, pest and diseases. Few farmers reported soil infertility and water logging as causes.

### Yield loss by drought

Figure-3-25 is a scatter plot of the Ln yield versus farmers' perception of yield loss due to drought. It features an increasing trend line. This indicates that the farmers' perception of increase in loss due to drought, increases with higher achieved yields, i.e. farmers obtaining higher yields perceived they suffered higher losses, whereas others obtaining low

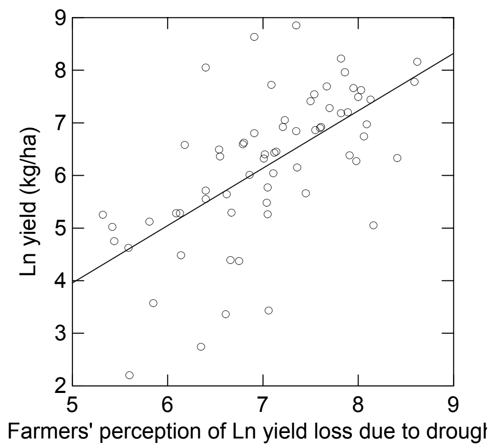


**Figure 3-25: Farmers' perception of Ln yield loss due to drought against Ln yield obtained**

yields perceived to have lower losses. It is significant with $P<0.05$ and $R^2 = 0.39$ in exploratory simple regression analysis.

An explanation of the unexpected and contradictory significant finding is that farmers, who are not aware that they could actually achieve high yields, also got the lowest possible yields. They ('A' farmers) in Figure 3.26 perceived that their yields are always low and that they loose nothing even if rainfall is poor. They seem to be still below the initial stages of development.

In contrary, the situation of ('B' farmers) as indicated in Figure 3-26 who are already on the inclining path of development, and who obtained relatively higher yields perceived that they incured considerable losses due to drought.

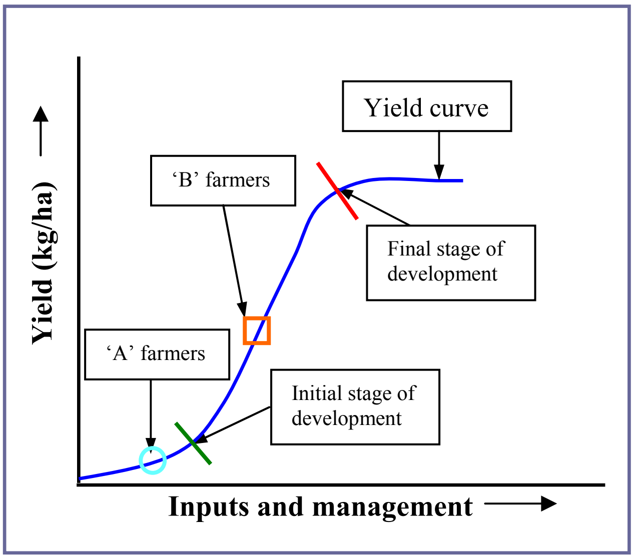


**Figure 3-26: Explanation of farmers' situation and perception on yield gap**

## Yield loss by pest and diseases

Figure-3-27 is a scatter plot of Ln yields against 40 farmers' perception of yield loss due to pest and diseases. It also features on increasing trend line. This indicates that the farmers' perception of increase in loss due to pest and diseases increases when higher actual yields are achieved. Simple regression shows a significant relation at $P<0.05$ with $R^2 = 0.52$.

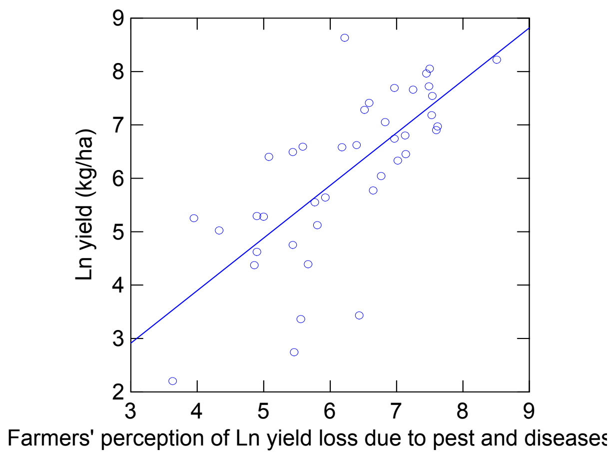


**Figure 3-27: Farmers' perception of Ln yield loss by pest & diseases and Ln yield obtained**

## 3.5 Summary of Descretive Statistics Results

Screened through the process of descriptive it was found that the following independent parameters have significant impact on maize yield (Table-3-3).

**Table 3-3: Summary of results obtained through descriptive statistics**

| **Ln yield (kg/ha) is: (each explanatory variables is tested individually)** | |
|---|---|
| - 0.725 | If plot size (ha) increase |
| +1.132 | If soil texture is heavy |
| - 0.973 | Four or more than four seeds used in a plant hill |
| +0.963 | If thinning is done |
| +0.841 | If weeded twice instead of once |
| +1.091 | Farmers' perception of yield loss due to drought |
| +0.506 | Farmers' perception of yield loss due to pest and diseases |

Other independent parameters that are non-significant but look promising in the multiple regression are listed in Table 3-4.

**Table 3-4: Non-significant but promising independent parameters**

| **Coefficient** | **Independent Parameters** |
|---|---|
| 0.709826 | If plots located within irrigation scheme |
| -0.491075 | If soil texture is light |
| -0.987700 | If soil texture is medium |
| 0.520365 | If animals are use in ploughing |
| 0.527604 | If animals are use in planting |
| 0.309005 | If line planting is done |

# 4. Multiple Regression

A series of multiple linear forward regression routine were done to derive a model to identify land and management factors that affect yield of Maize in the Limpopo valley. Stepwise forward multiple regression was used to select the independent parameters that are significantly related to Ln (yield). In the trial and error multiple stepwise forward regression, all the significant parameters as well as non-significant but promising parameters as discussed in the previous chapter were used. The model rejected non-significant parameters and kept significant ones though some carried wrong or unexpected signs.

An example of a parameter is "farmers' perception of yield loss due to pest and diseases". The values increases, it has regression coefficient of +0.53kg/ha. (Figure 3-25) A similar relation was observed concerning the regarding farmers' perception of yield loss due to drought. Though significant these relation are not logical. It was decided to exclude then from the production model.

## 4.1 The production model

Out of 13 tested land and management parameters, the final estimated model includes only four independent variables that significantly explained 57% (Adj. $R^2$ of 57%; p = 0.001) of the total yield variability (Table 4-1). The standard of Ln (yield) error is 0.261. Figure 4-1 shows the normal plot of observed and expected Ln (yields).

**The production model:**

**Ln yield (kg/ha) = 7.810- 0.689*Nosh- 0.720*Aha+1.121*H+0.955*Thng1**

**Where:**

| | |
|---|---|
| **Nosh** | - Number of seeds used in a hill |
| **Aha** | - Plot size cultivated (ha.) |
| **H** | - If heavy textured soil |
| **Thng1** | - If thinning practiced |

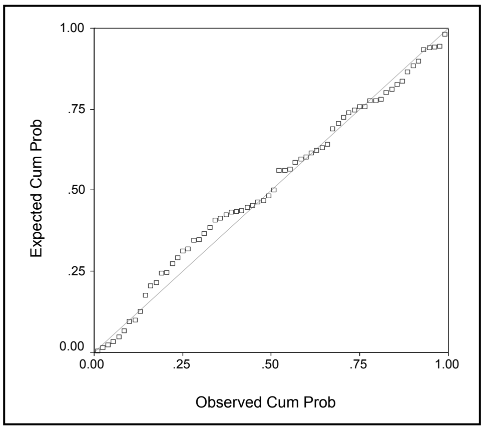


**Figure 4-1: The normal plot of observed and expected Ln yields**

**Table 4-1: Summary of final regression model causes Maize yield variation in 2002/2003 in summer season**

| Multiple linear regression<br>Dependent variable = Ln (yield) of maize<br>N=66<br>Method: Stepwise forward | | | $R^2$ = 60.3%<br>Adj. $R^2$ = 57.7%<br>S.E. = 0.261 |
|---|---|---|---|
| **Constant** | | | 7.810 |
| **Predictors** | **Coefficients** | **$R^2$ when entered** | **p-value** |
| No. of seeds used per hill | -0.689 | 21.3 | 0.000 |
| Plot size cultivated (ha) | -0.720 | 41.9 | 0.000 |
| If heavy texture soil | 1.121 | 51.6 | 0.000 |
| If thinning practice done | 0.955 | 60.3 | 0.001 |

The equation suggests that yields are higher if:

- Less number of seeds are used per hill while planting
- The plot size is smaller (manageable)
- Planted in heavy soil texture
- Thinning is done to reduce plant density per hill

## 4.2 Yield gap by yield constraints

Table 4-2 shows the estimated yield gap (kg/ha) and the contribution of each yield constraint to the overall yield gap. Using the production function and parameter statistics, 'average' and 'best' values were derived for each explanatory parameter (de Bie, 2000). Therefore, estimates of the respective contributions are based on comparisons of the average surveyed management with the best possible management. Difference in yield multiplied by the coefficient as estimated by the model indicates for a particular constraint its contribution to the overall yield gap.

**Table 4-2: Quantified break-down of the Maize yield gap by yield constraints (summer season 2002/2003)**

| Base on 66 sets of plot data | Parameter Statistics | | | Best values | x Coefficient | | Yield gap | | |
|---|---|---|---|---|---|---|---|---|---|
| Natural Ln yield (kg/ha) = | Min. | Max. | Mean | | Mean | Best | Ln (yield) | % | (kg/ha) |
| 7.810 Constant | | | 1 | 1 | 7.81 | 7.81 | | | |
| - 0.689 x No. of seeds used per hill | 2 | 4 | 2.95 | 2 | -2.04 | -1.38 | 0.66 | 30% | 1184 |
| - 0.720 x Plot size cultivated | 0.16 | 3.94 | 1.06 | 0.16 | -0.76 | -0.12 | 0.65 | 30% | 1163 |
| + 1.121 x If heavy soil texture | 0 | 1 | 0.47 | 1 | 0.53 | 1.12 | 0.59 | 27% | 1070 |
| +0.955 x If thinning done | 0 | 1 | 0.71 | 1 | 0.68 | 0.96 | 0.27 | 13% | 495 |
| | Estimated Ln yield | | | | 6.22 | 8.39 | 2.17 | | |
| | Actual Ln yield | | | | 6.22 | 8.85 | 2.63 | | |
| | Estimated yield (kg/ha) | | | | 503 | 4415 | | | 3912 |
| | Actual yield (kg/ha) | | | | 503 | 6963 | | | |
| | Sum | | | | | | | 100% | |

Note: Table format is being adopted after (de Bie, 2000)

The average estimated Ln (yield) by production model is 6.22kg/ha and potential is 8.39 kg/ha. After exponential conversion, it is 503kg/ha and 4415kg/ha with cobs respectively. The estimated total yield gap is 3912kg/ha. This value is used to re-calculate the relative contribution of each variable to the overall yield gap in non-logarithmic term (Yield gap in kg/ha=3912 * %). The exponential behaviour of the model suggests that the present production situations are not yet constrained by the law of "diminishing returns" (de Bie, 2000).

The estimated total yield gap (kg/ha) was caused by the following factors as shown in Figure 4-2.

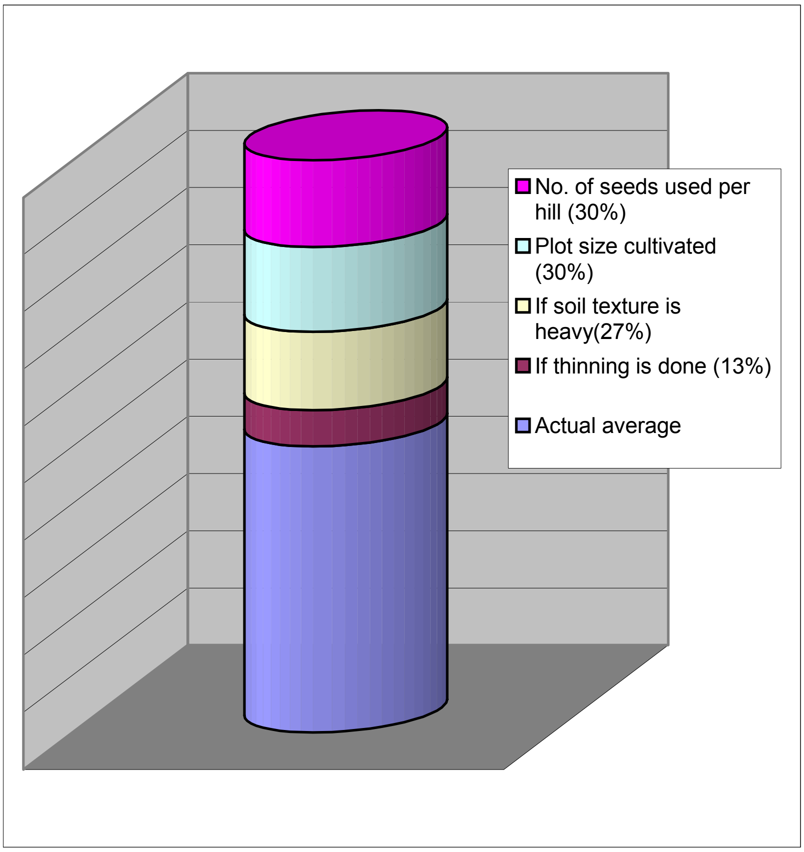


**Figure 4-2: Contribution of major constraints to the yield gap**

# 5. Model Validation

The data collected in the field covered two growing seasons. Season-wise separation was done at the time of data standardization. 71 interviews' data from the summer season were used to generate the production model. The remaining 27 interviews from the winter season are currently used to validate the production model. The model (Chapter 4) was used to estimate yields by entering by site the collected data of the four independent variables. Model validation is based on comparing this estimated yield with the actual reported yields by farmers.

Figure 5-1 shows the fit of this comparison. It shows that the model predicted with $R^2$ of 43% of the actual yield. The significant regression coefficient of 0.1973 with constant of 4.8 however shows that the winter season yields suffer from additional variability in yield due to aspects excluded from the model.

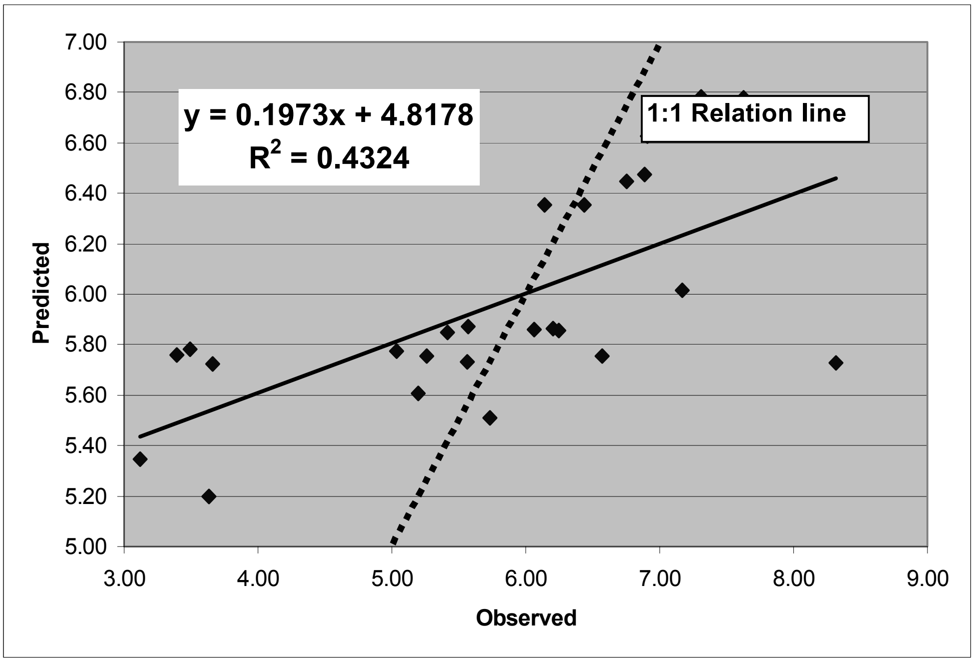


**Figure 5-1: Fitted model with data set of winter season with $R^2$ of 43%**

# 6. Discussion

## 6.1 Yield gap

The analysis of land and management parameters indicates that four biophysical factors significantly affected maize yields in the study area. None of the farmer reported to have achieved their expected yield. Most of the farmers are still below the initial stages of development and some are on the inclining stages of development. They are not aware that they could increase considerable amount of yield with reasonable management, care and suitable sites selection base on soil types.

### 6.1.1 Number of seeds per hill

In the study area, it was observed that farmers have traditional practices of planting more number of seeds (up to 6) in a hill. The study shows that 4 or more plants per hill is one of the significant limiting factors for maize productivity during summer season in the study area. 3 plants per hill has relatively higher yield. Highest was observed for two plants per hill. The production model suggests that 4 or more plants per hills reduces Ln yield of 0.698kg/ha. Planting more numbers of plants per hill probably reduces the sunlight absorption due to shading effect (Anonymous, 2001). Moreover, plants have to face more competition among them for available soil nutrient and water.

### 6.1.2 Cultivated plot size

Farmers cultivated plots ranging from 0.16 to 3.94 ha. with average of 1.04 ha. The study shows that the cultivated plot size is one of the significant limiting factors for maize productivity during summer season in the study area. As suggested by production model, increase in plot size reduces the Ln yield by 0.72 kg/ha. This is more assumed true in traditional agriculture practice of cultivation as observed in the study area in which operation and management aspect is labour intensive. When the area of the cultivated plot size is larger, the management becomes poor and untimely resulting in low yield. Moreover larger holdings are on the uplands where the soils are sandier with low population density (INGC, 2003). Mafalacusser (1995) also suggested the farm labour constraints in cultivating larger plots.

### 6.1.3 Soil texture

Soil texture is directly related with water holding capacity of the soil. Higher water holding capacity of soil means more water is available to the plants. Soil texture therefore, plays an important role during water stress season of the maize production. The study shows that the heavy soil texture is the most contributing factor for maize productivity during summer season of 2002/2003 of Limpopo valley. The heavy soil texture is most contributing factor in maize productivity as suggested by the model that the increase in Ln yield is 1.121 kg/ha. As suggested by Barron et al., (2003) that the dry spell in heavy texture soil is three-four times less often than light texture. This is in fact, inline with the field condition that the heavy texture soil distributed mostly on lowland. In addition with high water holding capacity, in valley ground water is not deep (Mafalacusser, 1995) that helps plant to intake water from the underground water table reducing drought stress (Anonymous, 2001). However, water logging in such soil is a problem during heavy rain (INGC, 2003).

Medium soil texture is supposed to be a good soil for agriculture with good drainage but it does not appear in the production model as a significant factor in this study. This type of soil is distributed more to the northern upland and patches on the transition zone to the south of lowland. Figure 3-5 shows the distribution of soil texture types. This soil texture seems to have lower average yield than light texture soil within the study area.

Light soil texture consists of sand and loamy sand which is considered to be poor for agricultural practice. However, this soil texture does not appear as significant limiting factor in this study. This type of soil is distributed mostly on the upland to the south of lowland (Limpopo flood plain) (Figure 3-5). The average maize yield is slightly higher in this soil type than medium texture soil within the study area.

### 6.1.4 Practice of Thinning

Though the farmers in the study area have traditional practices of planting more number of seeds in a hill, only some farmers practiced thinning. Thinning is the process of taking out extra number of plant from the field that are clustered in a hill or very close to each other. The study shows that the thinning practice is one of the significant contributing factors for maize productivity during summer season. The production model suggests that thinning practice increases Ln yield of maize by about 0.955kg/ha. Thinning could be done during weeding with earthing-up operation. Thinning facilitates plants to have more space for leaf spreading which enables absorption of more sunshine. This would enhance photosynthesis (Anonymous, 2001). Moreover, for even distribution of plants within a unit area facilitates uptake of nutrient and water from the soil. These would help proper growth and development of plants that may increase the yield.

## 6.2 Model validation

The production mode derived from summer growing season data set was tested with the data set of winter cropping season. This validation was done to check whether the land and management parameters significantly explaining the causes of yield gap in maize of summer season, could explain in the winter season. The application of the model on the data set of winter season gave $R^2$ of 43% (Observed vs. fitted). This fit seems good given a limited set of parameter, which had been considered in the model. It may have been helped due to most independent variables being independent of the season.

## 6.3 Limitation of the production model

The production model that explained significantly 57% of yield constraints has its own limitations. This model could explain only four land and management parameters significant effecting yield of maize in the study area. The most significant parameters-farmers perception of yield loss due to drought; yield loss due to pest and diseases could not be part of this model. All farmers reported drought was the main reason of yield gap but their perception of yield loss was not logical.

# 7. Conclusion and Recommendations

## 7.1 Conclusions

The CPA case study on maize yield gaps during 2002/2003-summer season in Limpopo valley identified four major biophysical constraints. Despite the limitation in the production model, the findings from the study are relevant within the context of the study site. The production model explains 57% of the yield variability with an average yield gap of 3912kg/ha. The impact of each identified constraint on yield was: number of seeds used in a plant hill (30%); plot size cultivated (30%); heavy soil texture (27%) and thinning practice done (13%). The traditional practice of using more seeds in a hill has negative impact on the yields. This indicates that farmers are not aware using less number of seeds in a hill but with closer spacing could obtain considerable higher yield. The larger plot size cultivated has negative impact on the yields. This means the farmers with larger plots could reduce considerable yield gap by improving management aspects in their field. Growing rain fed maize on heavy soil could increase yield. Thinning at appropriate stages can also narrow down yield gap in the study area. Frequency of weeding was not in the final model due to correlation with thinning practice. Land preparation aspects, variety grown, and other factor like flood-submerged areas had no evident impact on yield. Making the farmers aware about the cultural and managements aspects of the maize cultivation with proper production skills could narrow the yield gap.

## 7.2 Recommendations

The study on maize yield gap revealed that the cultivated plot size, growing on heavy soil texture, less no. of seeds in hill, and practice of thinning are important for improving maize yields. Therefore, to narrow the yield gap of maize in the study area, the following recommendations can be made:

- Farmers' awareness campaign about the production skill and suitable site selection based on soil for maize has to be made by agricultural extension programmes to the grassroots level in collaboration with agriculture land use planning.
- Future research should try to incorporate more parameters like soil fertility, application of FYM, chemical fertilizer, pesticides, and drought. This may result in a better model to explain yield gap.

# References


Albano, G. (2002). Reality and perspectives; Mozambique Country Report [Country Report]. TROPICAL SECONDARY FOREST MANAGEMENT IN AFRICA. Retrieved 25 December, 2003, from the World Wide Web: http://www.fao.org/DOCREP/006/J0628E/J0628E57.htm

An, N. T. (2000). Assesing spatial constraints leading to maize yield gaps: a case study of Hurungwe, Kanyati and Msampakaruma communal lands, Zimbabwe. MSc-thesis, ITC, Enschede.

Anonymous. (2001). Land Management for Grain Maize. Retrieved, 2003, from the World Wide Web: http://www.crop.cri.nz/psp/rbmp/maize/RBMPMaizeFactSheets.html

Anonymous. (2003, August 1, 2003). Mozambique-Geography. Retrieved 24 December, 2003, from the World Wide Web: http://www.country-facts.com/mz-geo.php

Asiema, J. (1994). "Africa's Green Revolution." Biotechnology and Development Monitor, No. 19, p. 17-18. Retrieved 20 June, 2003, from the World Wide Web: http://www.biotech-monitor.nl/new/index.php?link=publications

Barron, J., Rockstrom, J., Gichuki, F., & Hatibu, N. (2003). Dry spell analysis and maize yields for two semi-arid locations in east Africa. Agricultural and Forest Meteorology, 117(1-2), 23-37.

Becker, M., & Johnson, D. E. (1999). Rice yield and productivity gaps in irrigated systems of the forest zone of Cote d'Ivoire. Field Crops Research, 60(3), 201-208.

Bindraban, P. S., Stoorvogel, J. J., Jansen, D. M., Vlaming, J., & Groot, J. J. R. (2000). Land quality indicators for sustainable land management: proposed method for yield gap and soil nutrient balance. Agriculture, Ecosystems & Environment, 81(2), 103-112.

Bretel, S. L. (1997). Yield gap analysis for systems with maize, potato and wheat in the Belisario Boeto province, Chuquisaca, Bolivia. MSc-thesis, ITC, Enschede.

Casanova, D., Goudriaan, J., Bouma, J., & Epema, G. F. (1999). Yield gap analysis in relation to soil properties in direct-seeded flooded rice. Geoderma, 91(3-4), 191-216.

CIA. (2003, 19 March). The World Fact Book, 2002. Retrieved 3 July, 2003, from the World Wide Web: http://www.cia.gov/cia/publications/factbook/geos/mz.html#Intro

CIMMYT. (2002, November 2002). 1999/2000 World Maize Facts and Trends: Meeting World Maize Needs: Technological Opportunities and Priorities for the Public Sector. Retrieved 19 June, 2003, from the World Wide Web: http://www.cimmyt.org/Research/Economics/map/facts_trends/maizeft9900/html/maizeft9900_contents.htm

CIMMYT. (2003). CIMMYT Maize Program - International Maize Testing Unit, QPM Project Description. Retrieved 27 June, 2003, from the World Wide Web: http://148.223.253.105/qpmproject.htm#Project%20Benefits

de Bie, C. A. J. M. (2000). Comparative performance analysis of agro - ecosystems. PhD thesis, Wageningen University, The Netherelands. p-232.

de Bie, C. A. J. M. (2002). Novel approaches to use RS - products for mapping and studying agricultural land use systems.

FAO. (1996). World Food Summit: Source: FAO, November 1995. Retrieved 19-06-03, 2003, from the World Wide Web: http://www.fas.usda.gov/icd/summit/basic.html

FAO. (2000). EXPERT CONSULTATION ON YIELD GAP AND PRODUCTIVITY DECLINE IN RICE PRODUCTION, Rome, Italy, 5-7 September 2000. Retrieved 30 June, 2003, from the World Wide Web: http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPC/doc/field/commrice/session/53.htm

FAO. (2001). ASSESSMENT OF THE WORLD FOOD SECURITY SITUATION. Paper presented at the FAO-COMMITTEE ON WORLD FOOD SECURITY, Rome.

FAO. (2003). FAOSTAT STATISTICS DATABASE. Retrieved 23 June, 2003, from the World Wide Web: http://apps.fao.org/page/form?collection=Production.Crops.Primary&Domain=Production&servlet=1&language=EN&hostname=apps.fao.org&version=default

FAO/WFP. (2003). FAO/WFP CROP AND FOOD SUPPLY ASSESSMENT MISSION TO MOZAMBIQUE. Retrieved 10 July, from the World Wide Web: http://www.fao.org/docrep/005/y9729e/y9729e00.htm#6

FEWS. (2003, 27-02-02). FEWS Mozambique Food Security Update. Retrieved 19 June, 2003, from the World Wide Web: http://wwww.reliefweb.int/w/rwb.nsf/c7ca0eaf6c79faae852567af003c69ca/e41dd780b3f0671785256b7c005168ea?OpenDocument

Gaddi, G. M., Mundinamani, S. M., & Patil, S. A. (2002). Yield gaps, constraints and potential in cotton production in North Karnataka - An econometric analysis. Indian Journal of Agricultural Economics, 57(4), 722-734.

Girmay, A. (2000). Maize yield constraints in Makuwanpur district, Nepal. MSc-thesis, ITC, Enschede.

INE. (1999). RECENSEAMENTO GERAL DA POPULAÇÃO E HABITAÇÃO 1997 RESULTADOS DEFINITIVOS - GAZA (Digital). Maputo Moçambique.

INGC, U. E. M., FEWS.NET. (2003). Atlas for Disaster Preparedness and Response in the Limpopo Basin. Cape Town, South Africa: INGC, UNIVERSIDADE EDUARDO MONDLANE, FEWS.NET.

Mafalacusser, J. M. (1995). THE USE OF INDIGENOUS KNOWLEDGE FOR LAND USE PLANNING IN A PART OF XAI-XAI DISTRICT, GAZA PROVINCE, MOZAMBIQUE. M. Sc. Thesis, ITC, Enschede.

McCabe, M. a. (2002). INTRODUCTION TO THE PRACTICE OF STATISTICS, Purde University (fourth ed.): United State of America.

Pereira, J. J. F. (2002). Geographic impacts of the year 2000 great floods in the Limpopo river basin, Mozambique, Maputo: Deparamento de Geografia da Universidade Eduardo Mondlane.

Rockstrom, J., & Falkenmark, M. (2000). Semiarid Crop Production from a Hydrological Perspective: Gap between Potential and Actual Yields. Critical Reviews in Plant Sciences, 19(4), 319-346.

Rugege, D. (2002). Regional analysis of maize - based land use systems for early warning applications. PhD thesis, Wageningen University, Wageningen.

Spencer, B. (2002). Geo solutions. Geo Asia Pasific. Retrieved 16 December, 2003, from the World Wide Web: http://www.geoplace.com/asiapac/2000/0700/0700sol.asp

Thien, S. J. (1979). SOIL 252L Lab Manual, Flow chart for determining soil texture by feel. A flow diagram for teaching texture-by-feel analysis. New Mexico State University (NMSU), Agronomy and Horticulture (AGHT). Retrieved, 2003, from the World Wide Web: http://soil-physics.nmsu.edu/sp/classes/s252l/lab_manual/Chapt4.htm

Thompson, S. K. (1991). Adoptive Cluster sampling: Designs with Primary and Secondary Units.Unpublished manuscript.

Van Asten, P. J. A., Wopereis, M. C. S., Haefele, S., Ould Isselmou, M., & Kropff, M. J. (2003). Explaining yield gaps on farmer-identified degraded and non-degraded soils in a Sahelian irrigated rice scheme. Netherlands Journal of Agricultural Science, 50(3-4), 277-296.

Whiting, R. T. a. M. B. (2002). Soil Water Holding Capacity and Irrigation Management. Colorado State University, Cooperative Extension and Brent Mecham, Northern Colorado Water Conservancy District. Retrieved 11th December, 2003, from the World Wide Web: http://cmg.colostate.edu/factsheets/irrigation/I15-WaterHCapacity.pdf

Wokabi, E. v. R. (1994). Quantified land evaluation for maize yield gap analysis: at three sites on the eastern slope of Mount Kenya, PhD thesis University Ghent, and Summary in English. Enschede: ITC.

# Appendix

**APPENDIX I:** **Check List for land use survey**

**CHECKLIST**

**DATE : ………………………………SAMPLE No:……………………….**
**Farmer's NAME :………………………………Coordinates: X=……………………**
**VILLAGE NAME :………………………………. Y=……………………**

**1.GENERAL INFORMATION:**

Size of the field (GPS-iPAQ) measurement:…………….$m^2$

Soil texture (top 0-20cm) by auguring:…………………..

**2. CROP CALENDAR:**

How many crops did you grow last year? When?

**3. PLOUGHING:**

When did you start land preparation? How? Source of power? Number of ploughings?

**4. PLANTING:**

When did planting start? How? Source of power? Seeds per hill? Spacing? Variety?

Plant quality? (good/ average/ poor)

**6. THINNING**

Thinning done? (Yes/No), How many plants maintained per hill?

**7. WEEDING:**

When? How? How many times?

**8. HARVESTING:**

When? How?

**8. PRODUCTION:**

How much (kgs or bags)? How much expect? Why the difference? Reasons for differences?

- Drought; Pest and Diseases; Low soil fertility and
- Others (No oxen to plough, rats, over rain)

**If reports drought and pest & diseases then:**

- If there were only drought problem without pest and diseases, then what would be the production?

**9. FARM YARD MANURE (FYM) APPLICATION:**

When? How? How much?

**10. FERTILIZER APPLICATION:**

Number of fertilizer applications? When? How? Type? Quantity?

**11. APPLICATION OF PESTICIDES:**

When? Why? Names of pest/ disease? Control method? How?

**APPENDIX II: Codebook**

| Code | Full Label; source; how measured; etc. | Type | Unit |
|---|---|---|---|
| **General** | | | |
| **SL No.** | Serial number of the samples as 1, 2, 3,…………71 | Ratio | - |
| **ID** | Sample number given at the time of survey | Ratio | - |
| **X** | X-axis of the coordinates system captured by GPS | Ratio | m |
| **Y** | Y-axis of the coordinates system captured by GPS | Ratio | m |
| **NoR** | Name of the respondents, directly interviewed to the farmers | Nominal | - |
| **Sex** | Gender of the respondents | Nominal | - |
| **Vill** | Name of the village in which the plots belongs to. | Nominal | - |
| **Ame** | Plot Area; captured by MobileGIS | Ratio | Sq-M |
| **Aha** | Plot Area in hectare; captured by MobileGIS | Ratio | Ha |
| | | | |
| **Lish** | Located in the Irrigation Scheme. **(y=Yes; n=No)** | Ordinal | Binary |
| **Lish1** | If **"y"** then **"1"**, if **"n"** then **"0"** | Ordinal | Binary |
| | | | |
| **Fld2** | Flooded in the year 2000. Data generated by overlaying the sampled plots on the flood map of 2000. **(y=Yes; n=No)** | Ordinal | Binary |
| **Fld1** | If **"y"** then **"1"**, if **"n"** then **"0"** | | |
| | | | |
| **Soil and its parameters** | | | |
| **ST** | Soil texture; topsoil (0-20cm) in the field by feel method as in Thien, 1979. Agronomy Journal<br>s=sandy sicl=silty clay loam<br>ls=loamy sand sic=silty clay<br>sl=sandy loam l=loam<br>scl=sandy clay loam cl=clay loam<br>sc=sandy clay c=clay<br>sil=silty loam | Nominal | - |
| **mST** | "ST" are merged into 3 class as:<br>Light=**L,** Medium=**M** and Heavy=**H** | Nominal | |
| **L**<br>**M**<br>**H** | If **" L"** then **"1"** otherwise **"0".**<br>If **"M"** then "**1"** otherwise **"0".**<br>If **"H"** then **"1"** otherwise **"0".** | Ordinal | Binary |
| | | | |
| **SpH** | Soil pH is been tested in the field by the use of Universal pH paper provide by ITC. One part of soil dissolved with 5 parts of water & check pH by dipping pH paper & compare the colour with which it tally | Ratio | - |
| **Ploughing before planting dates and power used** | | | |
| **pbp1** | Date of 1st ploughing before planting Maize **(actual date)** in numbers. | Interval | - |
| **1pbp** | If ploughing before planting then **"1"**, if only at the time of planting then **"0"** | Ordinal | Binary |

| | | | |
|---|---|---|---|
| **pbpu** | Power used for ploughing before planting. **(manual & animal)** | Nominal | |
| **pbpu1** | If **"animal"** then **"1"**, if **"manual"** then **"0"** | Ordinal | Binary |
| **P1daj** | Ploughing done (No. of days) after 01/01/2002 reference date | Interval | - |
| **Note:** power used remain same for all other operations of Maize | | | |
| | | | |
| **Planting operation and its parameters** | | | |
| **pltd** | Planted date as numbers | Interval | - |
| **ptdaj** | Planting done (No. of days) after 01/01/2002 reference date | Interval | - |
| **ptdpl** | Planting (no. of days) after ploughing | Interval | - |
| **pltpu** | Power used during planting **(manual & animal)** | Nominal | - |
| **pltpu1** | If **"animal"** then **"1"**, if **"manual"** then **"0"** | Ordinal | Binary |
| **pltm** | Planting method **(hills** and **lines)** | Nominal | |
| **pltm1** | If **"lines"** then **"1"**, if **hills** then **"0"** | Ordinal | Binary |
| | | | |
| **Nosh** | No. of seeds used per plant hill. **2; 3;** and **4** more | Ratio | - |
| | | | |
| **spg** | Spacing (distance in cm. of one place to another of Maize used while planting) | Ratio | Cm |
| **phph** | Plants hills per hectare | Ratio | |
| | | | |
| **vu** | Variety used during planting **(Matuba=Ma, Local=Lo & Nhankuweini=Na)** | Nominal | - |
| **vu1** | If **"Lo"** then **"1"**; if **"Ma"** then **"2"**; if **"Na"** then **"3"** | Ratio | - |
| | | | |
| **Weeding and thinning operations** | | | |
| **Thng** | Thinning operation done during weeding **(Y=Yes, N=No)** | Ordinal | Binary |
| **Thng1** | If **"Y"** then **"1"**, if **"N"** then **"0"** | Ordinal | Binary |
| **wedg** | Weeding frequency **(Once or Twice)** | Nominal | - |
| **Tw** | If **"once"** then "**0"; if "Twice"** then **"1"** | Ordinal | Binary |
| | | | |
| **wdg1** | Start date of first weeding after planting in numbers | Interval | - |
| **w1dap** | 1st weeding (No. of days after planting) | Ratio | Day |
| **wdg2** | Start date of 2nd weeding after planting | Interval | - |
| **w2dap** | 2nd weeding (No. of days after planting) | Ratio | Day |
| **wdpu** | Power used in weeding (all by manual as **"mu"**) | Nominal | - |
| | | | |
| **Harvesting operation** | | | |
| **Hrvtd** | Reported date of last season Maize harvested as numbers | Interval | - |
| **hdaj1** | Harvesting (No. of days after 1st Jan-02) | Ratio | Day |
| **LGP** | The length of plant growing period (Harvesting date- Planting date) | Ratio | Day |

| | | | | |
|---|---|---|---|---|
| **Actual production reported** | | | | |
| | **apkg** | Actual production reported converted into kg as grain cum Cob's weight | Ratio | Kg |
| | **ayld** | Actual yield on farmers field | Ratio | Kg/ha |
| | **Ln yield** | Natural log of actual yield =**LN(ayld**) | Ratio | Kg/ha |
| | | | | |
| **Expected production by framers** | | | | |
| | **epkg** | Expected production converted in to kg | Ratio | Kg |
| | **eyld** | Expected yield by farmers in their fields | Ratio | Kg/ha |
| | | | | |
| **Farmers' perception on yield gap** | | | | |
| | **by drought:** | | | |
| | **pyld** | Percentage of yield loss due to drought | Ratio | |
| | **yldr** | Yield loss due to drought **= eyld* pyld /100** | Ratio | Kg/ha |
| | **Lnyldz** | Natural Ln of yield loss due to drought =**LN(yldr**) | Ratio | Kg/ha |
| | **by pest & diseases** | | | |
| | **pylpd** | Percentage of yield loss due to pest and diseases | Ratio | |
| | **ylpd** | Yield loss due to pest and diseases **= eyld* pylpd/100** | Ratio | Kg/ha |
| | **Lnylpz** | Natural Ln of yield loss due to pest and diseases =**LN(ylpd)** | Ratio | Kg/ha |
| | | | | |
| **Management practices** | | | | |
| | **Fym1** | If **"y=applied"** then **"1"**, if **"n=not applied"** then **"0"** | Ordinal | Binary |
| | | | | |
| | **Frti1** | If **"y=applied"** then **"1"**, if **"n=not applied"** then **"0"** | | |
| | | | | |
| | **Cpry1** | Chemical spray done for pest and diseases (P&D) control. If **"y**=Yes, sprayed**"** then **"1"**, if **"n**=No, not sprayed**"** then **"0"** | Ordinal | Binary |

## APPENDIX III: Spreadsheet of field data (Summer season 2002/2003)

| Sl No. | ID | X | Y | NoR | Sex | Village Name | Ame | Aha | Lish | Lish1 | Fld2 | Fld1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 92 | 537404 | 7266382 | Juliana Maringue | f | Chalucuane | 4790 | 0.48 | N | 0 | Y | 1 |
| 2 | 2 | 517826 | 7247720 | Arlindo Chemane | f | Mukokaluene | 4348 | 0.43 | N | 0 | N | 0 |
| 3 | 3 | 529887 | 7247600 | Eugenio Tivane | m | Makene | 5900 | 0.59 | N | 0 | N | 0 |
| 4 | 4 | 513979 | 7277872 | Antonio Mugabe | m | | 6096 | 0.61 | N | 0 | Y | 1 |
| 5 | 6 | 523714 | 7267151 | Maria Helena | f | Incovane | 5150 | 0.51 | Y | 1 | Y | 1 |
| 6 | 7 | 515806 | 7255588 | Ester Sibanda | f | Chihaquelane | 15299 | 1.53 | N | 0 | N | 0 |
| 7 | 8 | 521486 | 7271691 | Alberto Julio Tui | m | manganine | 27808 | 2.78 | Y | 1 | Y | 1 |
| 8 | 9 | 521403 | 7271497 | Gabriel Zimba | m | manganine | 19153 | 1.92 | Y | 1 | Y | 1 |
| 9 | 10 | 522557 | 7269020 | Albertina Chambal | f | chilembene | 20561 | 2.06 | Y | 1 | Y | 1 |
| 10 | 11 | 522684 | 7269227 | Zaida Vasco Hlamine | f | chilembene | 17268 | 1.73 | Y | 1 | Y | 1 |
| 11 | 12 | 524014 | 7268184 | Antonio Chambal | m | chilembene | 39384 | 3.94 | Y | 1 | Y | 1 |
| 12 | 13 | 524156 | 7268364 | Talita Mapsanganhe | f | chilembene | 16444 | 1.64 | Y | 1 | Y | 1 |
| 13 | 14 | 526532 | 7278138 | Etro Chambal | m | Chibabel | 31283 | 3.13 | N | 0 | Y | 1 |
| 14 | 15 | 526534 | 7277887 | Massado Muchanga | m | Chibabel | 7964 | 0.80 | N | 0 | Y | 1 |
| 15 | 16 | 525087 | 7278157 | Amelia Sambane | f | Chibabel | 10512 | 1.05 | N | 0 | Y | 1 |
| 16 | 17 | 525053 | 7277956 | Marta Tivane | f | Chibabel | 10438 | 1.04 | N | 0 | Y | 1 |
| 17 | 19 | 544118 | 7254225 | Ruth Enoque Zungueni | f | Mao-tse-tung | 8061 | 0.81 | N | 0 | Y | 1 |
| 18 | 21 | 544336 | 7253073 | Chichangue Domingos | m | Mao-tse-tung | 8751 | 0.88 | N | 0 | Y | 1 |
| 19 | 22 | 543980 | 7253905 | Francisco J. M. | m | Mao-tse-tung | 19716 | 1.97 | N | 0 | Y | 1 |
| 20 | 23 | 543358 | 7252123 | Eugenio F. Mate | m | Mao-tse-tung | 17439 | 1.74 | N | 0 | Y | 1 |
| 21 | 24 | 532484 | 7269932 | Precina Jacinto Sitoe | m | Chiguidela | 3781 | 0.38 | Y | 1 | Y | 1 |
| 22 | 25 | 532634 | 7270006 | Celina Pedro Mussane | f | Chiguidela | 7334 | 0.73 | Y | 1 | Y | 1 |
| 23 | 26 | 532679 | 7269978 | Jaime Machaeie | m | Chiguidela | 2707 | 0.27 | Y | 1 | Y | 1 |
| 24 | 27 | 532731 | 7270274 | Rafael Machaeie | m | Chiguidela | 4199 | 0.42 | Y | 1 | Y | 1 |
| 25 | 28 | 533099 | 7269668 | Filip Sitoe | m | Chiguidela | 11229 | 1.12 | Y | 1 | Y | 1 |
| 26 | 29 | 532241 | 7271235 | Ernesto Ualane | m | Chiguidela | 1580 | 0.16 | Y | 1 | Y | 1 |
| 27 | 30 | 531497 | 7270949 | Artur Zita | m | Chiguidela | 4186 | 0.42 | Y | 1 | Y | 1 |
| 28 | 31 | 552911 | 7237691 | Marta Uamusse | f | Chicumbane | 5842 | 0.58 | N | 0 | N | 0 |
| 29 | 32 | 551307 | 7237219 | Michel Bila | m | Chicumbane | 2385 | 0.24 | N | 0 | N | 0 |
| 30 | 37 | 519910 | 7237468 | Gloria Sitoe | f | Incaia | 3590 | 0.36 | N | 0 | N | 0 |
| 31 | 38 | 519801 | 7237418 | Melecina Cossa | f | Incaia | 6648 | 0.66 | N | 0 | N | 0 |
| 32 | 41 | 527857 | 7252665 | Fernando Nhangale | m | Olombe | 4451 | 0.45 | N | 0 | N | 0 |
| 33 | 42 | 527964 | 7252660 | Tomas Bombe | m | Olombe | 4767 | 0.48 | N | 0 | N | 0 |
| 34 | 44 | 526239 | 7257661 | Celeste Macamo | f | Massavane | 8999 | 0.90 | N | 0 | N | 0 |
| 35 | 45 | 525991 | 7257601 | Isabel Muteto | f | Massavane | 17227 | 1.72 | N | 0 | N | 0 |
| 36 | 46 | 523093 | 7261909 | Jose Fazenda Sitoe | m | Macunene | 17148 | 1.71 | N | 0 | N | 0 |
| 37 | 47 | 523424 | 7263008 | Helena Assa Chambal | f | Macunene | 9425 | 0.94 | N | 0 | Y | 1 |
| 38 | 48 | 513518 | 7261060 | Alfredo Mazive | f | Mapapa | 20789 | 2.08 | N | 0 | N | 0 |
| 39 | 49 | 513744 | 7260729 | Rafael Sitoe | m | Mapapa | 3402 | 0.34 | N | 0 | N | 0 |
| 40 | 50 | 513642 | 7260639 | Helena Chau | f | Mapapa | 3329 | 0.33 | N | 0 | N | 0 |
| 41 | 51 | 513718 | 7260785 | Antonio Chemule | m | Mapapa | 5106 | 0.51 | N | 0 | N | 0 |
| 42 | 52 | 512420 | 7247248 | Arlindo Rafael Sitoe | m | Mazivila(ns) | 4717 | 0.47 | N | 0 | N | 0 |
| 43 | 54 | 512460 | 7247393 | Laura Rafael Sitoe | f | Mazivila(ns) | 3192 | 0.32 | N | 0 | N | 0 |
| 44 | 63 | 548394 | 7269474 | Natercia S. Hlumalo | f | Macalavane | 2263 | 0.23 | N | 0 | Y | 1 |
| 45 | 64 | 548914 | 7269588 | Regina Macamu | f | Macalavane | 8685 | 0.87 | N | 0 | Y | 1 |
| 46 | 65 | 549434 | 7269735 | Sebastiao Biza | m | Macalavane | 3815 | 0.38 | N | 0 | Y | 1 |
| 47 | 66 | 549446 | 7269649 | Estania M. Sigauque | f | Macalavane | 3650 | 0.36 | N | 0 | Y | 1 |
| 48 | 67 | 549484 | 7269638 | Alice Alberto Balane | f | Macalavane | 3337 | 0.33 | N | 0 | Y | 1 |
| 49 | 68 | 545795 | 7269768 | Geordina F. Bila | f | Macalavane | 6687 | 0.67 | N | 0 | Y | 1 |
| 50 | 69 | 544607 | 7270847 | Muchaque Moiane | m | J-Macalauane | 6938 | 0.69 | N | 0 | Y | 1 |
| 51 | 70 | 544614 | 7271441 | Frazao Cossa | m | J-Macalauane | 12790 | 1.28 | N | 0 | Y | 1 |

| Sl No. | ID | X | Y | NoR | Sex | Village Name | Ame | Aha | Lish | Lish1 | Fld2 | Fld1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | 71 | 544554 | 7271181 | Solonao Chongo | m | J-Macalauane | 38092 | 3.81 | N | 0 | Y | 1 |
| 53 | 76 | 529577 | 7271553 | Albuquerque Muchanga | f | Chaimite | 12907 | 1.29 | N | 0 | Y | 1 |
| 54 | 80 | 530679 | 7276456 | Paulo Jorge Maibaze | m | Mohambe | 5894 | 0.59 | N | 0 | N | 0 |
| 55 | 81 | 530241 | 7274688 | Nordina Tivane | f | Mohambe | 11798 | 1.18 | N | 0 | Y | 1 |
| 56 | 82 | 531285 | 7279231 | Elisa Tivane | f | Gomba-Tlatlene | 5878 | 0.59 | N | 0 | Y | 1 |
| 57 | 83 | 531146 | 7279310 | Daniel Lucas Sonto | m | Gomba-Tlatlene | 22941 | 2.29 | N | 0 | Y | 1 |
| 58 | 84 | 530236 | 7279664 | Rosalina Mucachua | f | Gomba-Tlatlene | 16756 | 1.68 | N | 0 | Y | 1 |
| 59 | 87 | 525983 | 7279523 | Irene Bombe | f | Chibabel | 2110 | 0.21 | N | 0 | N | 0 |
| 60 | 88 | 526220 | 7279598 | Lucinda Sitoe | f | Chibabel | 6657 | 0.67 | N | 0 | N | 0 |
| 61 | 89 | 525785 | 7279266 | Afonso Joao Machava | m | Chibabel | 2677 | 0.27 | N | 0 | N | 0 |
| 62 | 90 | 527580 | 7281420 | Eugenio Benzane | m | Vuyaze | 8794 | 0.88 | N | 0 | Y | 1 |
| 63 | 91 | 527610 | 7281558 | Lidia Maueia | f | Vuyaze | 12549 | 1.25 | N | 0 | Y | 1 |
| 64 | 93 | 537031 | 7266050 | Angelina Mazive | f | Chalucuane | 17958 | 1.80 | N | 0 | Y | 1 |
| 65 | 94 | 536649 | 7266096 | Meledina Ualane | f | Chiguidela | 9767 | 0.98 | N | 0 | Y | 1 |
| 66 | 95 | 536332 | 7265833 | Nelson Zimba | m | Chalucuane | 2152 | 0.22 | N | 0 | Y | 1 |
| 67 | 96 | 542493 | 7255317 | Sortinho Machava | m | Mananganine | 4021 | 0.40 | N | 0 | N | 0 |
| 68 | 97 | 535771 | 7283102 | Andre Filipe Macamo | m | Chilattlo | 17739 | 1.77 | N | 0 | N | 0 |
| 69 | 98 | 536934 | 7280104 | Matilda Macamo | f | Chilattlo | 18795 | 1.88 | N | 0 | Y | 1 |
| 70 | 99 | 536326 | 7283063 | Vicente Bombe | m | Chilattlo | 4026 | 0.40 | N | 0 | N | 0 |
| 71 | 100 | 537195 | 7280074 | Atalia Sitoe | f | Chilattlo | 15571 | 1.56 | N | 0 | Y | 1 |

| ST | mST | L | M | H | SpH | pbp1 | 1pbp | pbpu | pbpu1 | p1daj | pltd | ptdaj | ptdpl | pltpu | pltpu1 | pltm | pltm1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| sicl | H | 0 | 0 | 1 | 6.7 | 37569 | 0 | animal | 1 | 312 | 37569 | 312 | 0 | manual | 0 | hill | 0 |
| s | L | 1 | 0 | 0 | 6 | 37508 | 1 | manual | 0 | 251 | 37544 | 287 | 36 | manual | 0 | hill | 0 |
| sl | M | 0 | 1 | 0 | 5.5 | 37508 | 1 | manual | 0 | 251 | 37554 | 297 | 46 | manual | 0 | hill | 0 |
| sicl | H | 0 | 0 | 1 | 5.5 | 37477 | 1 | animal | 1 | 220 | 37515 | 258 | 38 | animal | 1 | line | 1 |
| scl | H | 0 | 0 | 1 | 6.5 | 37531 | 1 | animal | 1 | 274 | 37552 | 295 | 21 | animal | 1 | line | 1 |
| s | L | 1 | 0 | 0 | 6.5 | 37501 | 1 | manual | 0 | 244 | 37531 | 274 | 30 | manual | 0 | hill | 0 |
| scl | H | 0 | 0 | 1 | 6.5 | 37501 | 1 | animal | 1 | 244 | 37538 | 281 | 37 | animal | 1 | line | 1 |
| scl | H | 0 | 0 | 1 | 6 | 37552 | 0 | animal | 1 | 295 | 37552 | 295 | 0 | animal | 1 | line | 1 |
| scl | H | 0 | 0 | 1 | 6.5 | 37538 | 1 | animal | 1 | 281 | 37569 | 312 | 31 | animal | 1 | line | 1 |
| cl | H | 0 | 0 | 1 | 6 | 37562 | 1 | animal | 1 | 305 | 37592 | 335 | 30 | animal | 1 | line | 1 |
| scl | H | 0 | 0 | 1 | 6 | 37569 | 1 | animal | 1 | 312 | 37569 | 312 | 0 | animal | 1 | line | 1 |
| scl | H | 0 | 0 | 1 | 6 | 37538 | 1 | animal | 1 | 281 | 37569 | 312 | 31 | manual | 0 | line | 1 |
| sl | M | 0 | 1 | 0 | 6.5 | 37508 | 1 | animal | 1 | 251 | 37531 | 274 | 23 | animal | 1 | line | 1 |
| sl | M | 0 | 1 | 0 | 6 | 37496 | 1 | manual | 0 | 239 | 37531 | 274 | 35 | manual | 0 | line | 1 |
| sicl | H | 0 | 0 | 1 | 7 | 37522 | 1 | manual | 0 | 265 | 37538 | 281 | 16 | manual | 0 | line | 1 |
| sicl | H | 0 | 0 | 1 | 6.5 | 37538 | 1 | manual | 0 | 281 | 37545 | 288 | 7 | manual | 0 | hill | 0 |
| cl | H | 0 | 0 | 1 | 6 | 37534 | 1 | manual | 0 | 277 | 37576 | 319 | 42 | manual | 0 | hill | 0 |
| sic | H | 0 | 0 | 1 | 5.5 | 37538 | 1 | manual | 0 | 281 | 37569 | 312 | 31 | manual | 0 | hill | 0 |
| sil | M | 0 | 1 | 0 | 6.5 | 37477 | 1 | animal | 1 | 220 | 37538 | 281 | 61 | animal | 1 | line | 1 |
| scl | H | 0 | 0 | 1 | 5.5 | 37477 | 1 | animal | 1 | 220 | 37545 | 288 | 68 | animal | 1 | line | 1 |
| sil | M | 0 | 1 | 0 | 7 | 37470 | 1 | animal | 1 | 213 | 37583 | 326 | 113 | animal | 1 | line | 1 |
| sic | H | 0 | 0 | 1 | 6.5 | 37501 | 1 | animal | 1 | 244 | 37562 | 305 | 61 | animal | 1 | line | 1 |
| sic | H | 0 | 0 | 1 | 6.5 | 37522 | 1 | animal | 1 | 265 | 37562 | 305 | 40 | animal | 1 | line | 1 |
| sicl | H | 0 | 0 | 1 | 7 | 37501 | 1 | animal | 1 | 244 | 37562 | 305 | 61 | animal | 1 | line | 1 |
| sicl | H | 0 | 0 | 1 | 7 | 37470 | 1 | animal | 1 | 213 | 37569 | 312 | 99 | animal | 1 | line | 1 |
| sicl | H | 0 | 0 | 1 | 6.5 | 37501 | 1 | manual | 0 | 244 | 37562 | 305 | 61 | manual | 0 | line | 1 |
| sic | H | 0 | 0 | 1 | 6.5 | 37531 | 1 | animal | 1 | 274 | 37583 | 326 | 52 | animal | 1 | line | 1 |
| ls | L | 1 | 0 | 0 | 6 | 37501 | 0 | animal | 1 | 244 | 37501 | 244 | 0 | manual | 0 | hill | 0 |
| ls | L | 1 | 0 | 0 | 6 | 37501 | 1 | manual | 0 | 244 | 37538 | 281 | 37 | manual | 0 | hill | 0 |
| ls | L | 1 | 0 | 0 | 6 | 37501 | 1 | manual | 0 | 244 | 37569 | 312 | 68 | manual | 0 | hill | 0 |
| ls | L | 1 | 0 | 0 | 6.5 | 37508 | 1 | manual | 0 | 251 | 37562 | 305 | 54 | manual | 0 | hill | 0 |
| s | L | 1 | 0 | 0 | 6.5 | 37470 | 1 | manual | 0 | 213 | 37531 | 274 | 61 | manual | 0 | hill | 0 |
| s | L | 1 | 0 | 0 | 6 | 37470 | 1 | manual | 0 | 213 | 37545 | 288 | 75 | manual | 0 | hill | 0 |
| s | L | 1 | 0 | 0 | 6 | 37501 | 1 | manual | 0 | 244 | 37552 | 295 | 51 | animal | 1 | line | 1 |
| s | L | 1 | 0 | 0 | 6 | 37484 | 1 | animal | 1 | 227 | 37538 | 281 | 54 | animal | 1 | line | 1 |
| sl | M | 0 | 1 | 0 | 5.5 | 37522 | 1 | animal | 1 | 265 | 37552 | 295 | 30 | animal | 1 | line | 1 |
| sl | M | 0 | 1 | 0 | 5 | 37470 | 1 | animal | 1 | 213 | 37569 | 312 | 99 | animal | 1 | line | 1 |
| ls | L | 1 | 0 | 0 | 6 | 37508 | 1 | animal | 1 | 251 | 37552 | 295 | 44 | animal | 1 | line | 1 |
| ls | L | 1 | 0 | 0 | 6.5 | 37501 | 1 | manual | 0 | 244 | 37538 | 281 | 37 | manual | 0 | hill | 0 |
| ls | L | 1 | 0 | 0 | 6.5 | 37446 | 1 | manual | 0 | 189 | 37470 | 213 | 24 | manual | 0 | hill | 0 |
| s | L | 1 | 0 | 0 | 6.5 | 37460 | 1 | manual | 0 | 203 | 37470 | 213 | 10 | manual | 0 | hill | 0 |
| s | L | 1 | 0 | 0 | 6.5 | 37484 | 1 | manual | 0 | 227 | 37508 | 251 | 24 | manual | 0 | hill | 0 |
| ls | L | 1 | 0 | 0 | 6.5 | 37409 | 1 | manual | 0 | 152 | 37477 | 220 | 68 | manual | 0 | hill | 0 |
| sicl | H | 0 | 0 | 1 | 6 | 37484 | 1 | animal | 1 | 227 | 37508 | 251 | 24 | animal | 1 | line | 1 |
| sic | H | 0 | 0 | 1 | 6.5 | 37477 | 1 | animal | 1 | 220 | 37522 | 265 | 45 | animal | 1 | line | 1 |
| sic | H | 0 | 0 | 1 | 6 | 37470 | 1 | animal | 1 | 213 | 37508 | 251 | 38 | animal | 1 | line | 1 |
| sic | H | 0 | 0 | 1 | 6.5 | 37470 | 1 | manual | 0 | 213 | 37508 | 251 | 38 | manual | 0 | hill | 0 |
| sic | H | 0 | 0 | 1 | 6.5 | 37470 | 1 | animal | 1 | 213 | 37508 | 251 | 38 | animal | 1 | line | 1 |
| l | M | 0 | 1 | 0 | 6.5 | 37416 | 1 | animal | 1 | 159 | 37538 | 281 | 122 | animal | 1 | line | 1 |
| l | M | 0 | 1 | 0 | 6.5 | 37378 | 1 | manual | 0 | 121 | 37515 | 258 | 137 | manual | 0 | line | 1 |
| l | M | 0 | 1 | 0 | 6.7 | 37392 | 1 | manual | 0 | 135 | 37515 | 258 | 123 | manual | 0 | hill | 0 |

| ST | mST | L | M | H | SpH | pbp1 | 1pbp | pbpu | pbpu1 | p1daj | pltd | ptdaj | ptdpl | pltpu | pltpu1 | pltm | pltm1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| l | M | 0 | 1 | 0 | 6.5 | 37324 | 1 | manual | 0 | 67 | 37515 | 258 | 191 | manual | 0 | hill | 0 |
| sicl | H | 0 | 0 | 1 | 7 | 37484 | 1 | animal | 1 | 227 | 37545 | 288 | 61 | animal | 1 | hill | 0 |
| sil | M | 0 | 1 | 0 | 6.8 | 37515 | 0 | animal | 1 | 258 | 37515 | 258 | 0 | animal | 1 | line | 1 |
| sic | H | 0 | 0 | 1 | 7 | 37501 | 0 | animal | 1 | 244 | 37501 | 244 | 0 | manual | 0 | hill | 0 |
| sicl | H | 0 | 0 | 1 | 6.8 | 37416 | 1 | animal | 1 | 159 | 37538 | 281 | 122 | animal | 1 | line | 1 |
| sicl | H | 0 | 0 | 1 | 6.8 | 37430 | 1 | animal | 1 | 173 | 37545 | 288 | 115 | animal | 1 | line | 1 |
| ls | L | 1 | 0 | 0 | 6.9 | 37515 | 1 | animal | 1 | 258 | 37545 | 288 | 30 | animal | 1 | line | 1 |
| s | L | 1 | 0 | 0 | 5 | 37477 | 1 | manual | 0 | 220 | 37538 | 281 | 61 | manual | 0 | line | 1 |
| s | L | 1 | 0 | 0 | 5.5 | 37477 | 1 | animal | 1 | 220 | 37538 | 281 | 61 | animal | 1 | line | 1 |
| s | L | 1 | 0 | 0 | 6 | 37470 | 1 | manual | 0 | 213 | 37531 | 274 | 61 | manual | 0 | hill | 0 |
| ls | L | 1 | 0 | 0 | 6.5 | 37552 | 1 | animal | 1 | 295 | 37562 | 305 | 10 | animal | 1 | line | 1 |
| ls | L | 1 | 0 | 0 | 6.5 | 37538 | 1 | manual | 0 | 281 | 37562 | 305 | 24 | manual | 0 | hill | 0 |
| sicl | H | 0 | 0 | 1 | 6.8 | 37552 | 0 | animal | 1 | 295 | 37552 | 295 | 0 | manual | 0 | line | 1 |
| l | M | 0 | 1 | 0 | 6.8 | 37484 | 1 | manual | 0 | 227 | 37562 | 305 | 78 | manual | 0 | hill | 0 |
| cl | H | 0 | 0 | 1 | 6.8 | 37501 | 1 | manual | 0 | 244 | 37538 | 281 | 37 | manual | 0 | hill | 0 |
| ls | L | 1 | 0 | 0 | 6.9 | 37477 | 1 | animal | 1 | 220 | 37538 | 281 | 61 | animal | 1 | line | 1 |
| sl | M | 0 | 1 | 0 | 6.8 | 37470 | 1 | animal | 1 | 213 | 37515 | 258 | 45 | animal | 1 | line | 1 |
| sil | M | 0 | 1 | 0 | 5.8 | 37508 | 1 | animal | 1 | 251 | 37531 | 274 | 23 | animal | 1 | line | 1 |
| sc | H | 0 | 0 | 1 | 6 | 37538 | 1 | animal | 1 | 281 | 37552 | 295 | 14 | animal | 1 | line | 1 |
| sil | M | 0 | 1 | 0 | 6.3 | 37501 | 1 | animal | 1 | 244 | 37538 | 281 | 37 | animal | 1 | line | 1 |

| Nosh | spg | phph | vu | vu1 | Thng | Thng1 | wedg | Tw | wdg1 | w1dap | wdg2 | w2dap | wdpu | Hrvtd | hdaj1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 100 | 10000 | Lo | 1 | N | 0 | Twice | 1 | 37623 | 54 | 37654 | 85 | mu | 37703 | 446 |
| 4 | 100 | 10000 | Lo | 1 | N | 0 | Once | 0 | 37575 | 31 | | | mu | 37667 | 410 |
| 3 | 70 | 20408 | Lo | 1 | N | 0 | Once | 0 | 37569 | 15 | | | mu | 37644 | 387 |
| 2 | 45 | 49383 | Lo | 1 | N | 0 | Twice | 1 | 37544 | 29 | 37575 | 60 | mu | 37599 | 342 |
| 3 | 50 | 40000 | Lo | 1 | Y | 1 | Once | 0 | 37592 | 40 | | | mu | | |
| 3 | 60 | 27778 | Lo | 1 | N | 0 | Twice | 1 | 37592 | 61 | 37630 | 99 | mu | 37696 | 439 |
| 3 | 50 | 40000 | Lo | 1 | N | 0 | Once | 0 | 37576 | 38 | | | mu | 37613 | 356 |
| 3 | 60 | 27778 | Lo | 1 | N | 0 | Once | 0 | 37583 | 31 | | | mu | 37623 | 366 |
| 3 | 50 | 40000 | Lo | 1 | N | 0 | Twice | 1 | 37623 | 54 | 37661 | 92 | mu | 37696 | 439 |
| 3 | 55 | 33058 | Ma | 2 | Y | 1 | Twice | 1 | 37613 | 21 | 37661 | 69 | mu | 37703 | 446 |
| 3 | 50 | 40000 | Ma | 2 | Y | 1 | Twice | 1 | 37623 | 54 | 37661 | 92 | mu | 37703 | 446 |
| 3 | 50 | 40000 | Ma | 2 | Y | 1 | Twice | 1 | 37623 | 54 | 37682 | 113 | mu | 37713 | 456 |
| 2 | 45 | 49383 | Lo | 1 | N | 0 | Once | 0 | 37552 | 21 | | | mu | 37613 | 356 |
| 4 | 50 | 40000 | Lo | 1 | N | 0 | Twice | 1 | 37562 | 31 | 37599 | 68 | mu | 37630 | 373 |
| 3 | 50 | 40000 | Lo | 1 | N | 0 | Twice | 1 | 37562 | 24 | 37592 | 54 | mu | 37637 | 380 |
| 3 | 60 | 27778 | Lo | 1 | N | 0 | Twice | 1 | 37576 | 31 | 37606 | 61 | mu | 37637 | 380 |
| 3 | 70 | 20408 | Lo | 1 | N | 0 | Twice | 1 | 37613 | 37 | 37623 | 47 | mu | 37668 | 411 |
| 3 | 75 | 17778 | Lo | 1 | Y | 1 | Twice | 1 | 37599 | 30 | 37623 | 54 | mu | 37727 | 470 |
| 2 | 80 | 15625 | Lo | 1 | Y | 1 | Twice | 1 | 37569 | 31 | 37606 | 68 | mu | 37637 | 380 |
| 2 | 75 | 17778 | Lo | 1 | Y | 1 | Twice | 1 | 37583 | 38 | 37599 | 54 | mu | 37637 | 380 |
| 3 | 60 | 27778 | Lo | 1 | Y | 1 | Twice | 1 | 37599 | 16 | 37623 | 40 | mu | 37696 | 439 |
| 2 | 70 | 20408 | Lo | 1 | Y | 1 | Twice | 1 | 37592 | 30 | 37623 | 61 | mu | 37682 | 425 |
| 2 | 60 | 27778 | Lo | 1 | Y | 1 | Twice | 1 | 37583 | 21 | 37623 | 61 | mu | 37682 | 425 |
| 2 | 50 | 40000 | Lo | 1 | Y | 1 | Twice | 1 | 37592 | 30 | 37623 | 61 | mu | 37682 | 425 |
| 2 | 50 | 40000 | Lo | 1 | Y | 1 | Twice | 1 | 37592 | 23 | 37623 | 54 | mu | 37682 | 425 |
| 2 | 40 | 62500 | Lo | 1 | Y | 1 | Twice | 1 | 37592 | 30 | 37623 | 61 | mu | 37661 | 404 |
| 2 | 60 | 27778 | Lo | 1 | Y | 1 | Twice | 1 | 37599 | 16 | 37623 | 40 | mu | 37661 | 404 |
| 4 | 150 | 4444 | Lo | 1 | Y | 1 | Once | 0 | 37538 | 37 | | | mu | 37592 | 335 |
| 3 | 50 | 40000 | Lo | 1 | Y | 1 | Twice | 1 | 37562 | 24 | 37606 | 68 | mu | 37630 | 373 |
| 4 | 130 | 5917 | Lo | 1 | Y | 1 | Once | 0 | 37606 | 37 | | | mu | 37668 | 411 |
| 3 | 140 | 5102 | Lo | 1 | Y | 1 | Once | 0 | 37599 | 37 | | | mu | 37644 | 387 |
| 2 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37576 | 45 | 37599 | 68 | mu | 37623 | 366 |
| 4 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37569 | 24 | 37637 | 92 | mu | | |
| 3 | 90 | 12346 | Lo | 1 | Y | 1 | Twice | 1 | 37576 | 24 | 37613 | 61 | mu | | |
| 2 | 50 | 40000 | Lo | 1 | Y | 1 | Once | 0 | 37637 | 99 | | | mu | 37675 | 418 |
| 3 | 60 | 27778 | Lo | 1 | Y | 1 | Twice | 1 | 37583 | 31 | 37613 | 61 | mu | 37630 | 373 |
| 3 | 60 | 27778 | Lo | 1 | Y | 1 | Once | 0 | 37623 | 54 | | | mu | 37644 | 387 |
| 3 | 80 | 15625 | Lo | 1 | Y | 1 | Twice | 1 | 37606 | 54 | 37637 | 85 | mu | 37668 | 411 |
| 3 | 60 | 27778 | Lo | 1 | Y | 1 | Twice | 1 | 37562 | 24 | 37613 | 75 | mu | 37644 | 387 |
| 3 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37531 | 61 | 37562 | 92 | mu | 37599 | 342 |
| 3 | 70 | 20408 | Lo | 1 | Y | 1 | Twice | 1 | 37508 | 38 | 37531 | 61 | mu | 37583 | 326 |
| 3 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37562 | 54 | 37606 | 98 | mu | 37661 | 404 |
| 3 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37545 | 68 | 37569 | 92 | mu | 37613 | 356 |
| 3 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37531 | 23 | 37552 | 44 | mu | 37630 | 373 |
| 4 | 90 | 12346 | Lo | 1 | Y | 1 | Twice | 1 | 37538 | 16 | 37583 | 61 | mu | 37644 | 387 |
| 2 | 120 | 6944 | Lo | 1 | N | 0 | Twice | 1 | 37531 | 23 | 37552 | 44 | mu | 37599 | 342 |
| 2 | 60 | 27778 | Lo | 1 | Y | 1 | Twice | 1 | 37538 | 30 | 37562 | 54 | mu | 37637 | 380 |
| 3 | 70 | 20408 | Lo | 1 | Y | 1 | Once | 0 | 37562 | 54 | | | mu | 37630 | 373 |
| 4 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37583 | 45 | 37613 | 75 | mu | 37644 | 387 |
| 4 | 70 | 20408 | Lo | 1 | N | 0 | Twice | 1 | 37545 | 30 | 37562 | 47 | mu | 37606 | 349 |
| 4 | 100 | 10000 | Lo | 1 | N | 0 | Twice | 1 | 37545 | 30 | 37569 | 54 | mu | 37592 | 335 |

| Nosh | spg | phph | vu | vu1 | Thng | Thng1 | wedg | Tw | wdg1 | w1dap | wdg2 | w2dap | wdpu | Hrvtd | hdaj1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37538 | 23 | 37562 | 47 | mu | 37599 | 342 |
| 4 | 90 | 12346 | Lo | 1 | N | 0 | Once | 0 | 37576 | 31 | | | mu | 37668 | 411 |
| 3 | 95 | 11080 | Lo | 1 | Y | 1 | Twice | 1 | 37538 | 23 | 37569 | 54 | mu | 37599 | 342 |
| 4 | 90 | 12346 | Lo | 1 | N | 0 | Twice | 1 | 37522 | 21 | 37552 | 51 | mu | 37644 | 387 |
| 3 | 110 | 8264 | Lo | 1 | Y | 1 | Twice | 1 | 37592 | 54 | 37630 | 92 | mu | 37668 | 411 |
| 3 | 120 | 6944 | Lo | 1 | Y | 1 | Twice | 1 | 37599 | 54 | 37644 | 99 | mu | 37654 | 397 |
| 4 | 60 | 27778 | Lo | 1 | Y | 1 | Twice | 1 | 37583 | 38 | 37613 | 68 | mu | 37644 | 387 |
| 3 | 80 | 15625 | Lo | 1 | Y | 1 | Once | 0 | 37569 | 31 | | | mu | 37689 | 432 |
| 3 | 70 | 20408 | Lo | 1 | Y | 1 | Once | 0 | 37569 | 31 | | | mu | 37696 | 439 |
| 3 | 50 | 40000 | Lo | 1 | Y | 1 | Twice | 1 | 37576 | 45 | 37613 | 82 | mu | 37675 | 418 |
| 3 | 85 | 13841 | Lo | 1 | Y | 1 | Once | 0 | 37599 | 37 | | | mu | | |
| 3 | 100 | 10000 | Lo | 1 | Y | 1 | Once | 0 | 37599 | 37 | | | mu | | |
| 4 | 50 | 40000 | Na | 3 | Y | 1 | Twice | 1 | 37583 | 31 | 37599 | 47 | mu | 37668 | 411 |
| 3 | 90 | 12346 | Na | 3 | Y | 1 | Twice | 1 | 37583 | 21 | 37599 | 37 | mu | 37675 | 418 |
| 3 | 50 | 40000 | Na | 3 | N | 0 | Twice | 1 | 37552 | 14 | 37576 | 38 | mu | 37630 | 373 |
| 3 | 90 | 12346 | Lo | 1 | Y | 1 | Twice | 1 | 37583 | 45 | 37613 | 75 | mu | 37637 | 380 |
| 3 | 100 | 10000 | Lo | 1 | Y | 1 | Once | 0 | 37562 | 47 | | | mu | 37675 | 418 |
| 4 | 90 | 12346 | Lo | 1 | Y | 1 | Once | 0 | 37576 | 45 | | | mu | 37613 | 356 |
| 3 | 90 | 12346 | Lo | 1 | Y | 1 | Once | 0 | 37606 | 54 | | | mu | 37644 | 387 |
| 3 | 85 | 13841 | Lo | 1 | Y | 1 | Once | 0 | 37569 | 31 | | | mu | 37623 | 366 |

| LGP | apkg | ayld | Ln yield | epkg | eyld | pyld | yldr | Lnyldz | pylpd | ylpd | Lnylpz | Fym1 | Frti1 | Cpry1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 134 | 900 | 1879 | 7.54 | 1800 | 3758 | 50 | 1879 | 7.54 | 50 | 1879 | 7.54 | 0 | 0 | 0 |
| 123 | 15 | 35 | 3.57 | 150 | 345 | 100 | 345 | 5.85 | 0 | 0 | | 0 | 1 | 0 |
| 90 | 240 | 407 | 6.01 | 560 | 949 | 100 | 949 | 6.86 | 0 | 0 | | 0 | 0 | 0 |
| 84 | 400 | 656 | 6.49 | 560 | 919 | 75 | 689 | 6.54 | 25 | 230 | 5.44 | 0 | 0 | 0 |
| | 0 | 0 | | 400 | 777 | 100 | 777 | 6.66 | 0 | 0 | | 1 | 0 | 0 |
| 165 | 300 | 196 | 5.28 | 700 | 458 | 100 | 458 | 6.13 | 0 | 0 | | 0 | 0 | 1 |
| 75 | 320 | 115 | 4.75 | 1280 | 460 | 50 | 230 | 5.44 | 50 | 230 | 5.44 | 0 | 0 | 0 |
| 71 | 320 | 167 | 5.12 | 1280 | 668 | 50 | 334 | 5.81 | 50 | 334 | 5.81 | 0 | 0 | 0 |
| 127 | 1920 | 934 | 6.84 | 3200 | 1556 | 100 | 1556 | 7.35 | 0 | 0 | | 0 | 0 | 0 |
| 111 | 1000 | 579 | 6.36 | 1200 | 695 | 100 | 695 | 6.55 | 0 | 0 | | 0 | 0 | 0 |
| 134 | 750 | 190 | 5.25 | 1000 | 254 | 80 | 203 | 5.32 | 20 | 51 | 3.95 | 0 | 0 | 0 |
| 144 | 1200 | 730 | 6.59 | 2640 | 1605 | 56 | 892 | 6.79 | 17 | 268 | 5.59 | 0 | 0 | 0 |
| 82 | 25 | 8 | 2.20 | 960 | 307 | 88 | 269 | 5.60 | 12 | 38 | 3.63 | 0 | 0 | 0 |
| 99 | 80 | 100 | 4.62 | 320 | 402 | 67 | 268 | 5.59 | 33 | 134 | 4.90 | 0 | 0 | 0 |
| 99 | 250 | 238 | 5.48 | 1200 | 1142 | 100 | 1142 | 7.04 | 0 | 0 | | 0 | 0 | 0 |
| 92 | 200 | 192 | 5.26 | 1200 | 1150 | 100 | 1150 | 7.05 | 0 | 0 | | 0 | 0 | 0 |
| 92 | 500 | 620 | 6.43 | 1000 | 1241 | 100 | 1241 | 7.12 | 0 | 0 | | 0 | 0 | 0 |
| 158 | 250 | 286 | 5.66 | 1500 | 1714 | 100 | 1714 | 7.45 | 0 | 0 | | 0 | 0 | 0 |
| 92 | 3250 | 1648 | 7.41 | 5000 | 2536 | 71 | 1811 | 7.50 | 29 | 725 | 6.59 | 0 | 0 | 0 |
| 92 | 5000 | 2867 | 7.96 | 7500 | 4301 | 60 | 2580 | 7.86 | 40 | 1720 | 7.45 | 0 | 0 | 0 |
| 113 | 200 | 529 | 6.27 | 1100 | 2909 | 100 | 2909 | 7.98 | 0 | 0 | | 0 | 0 | 0 |
| 120 | 1500 | 2045 | 7.62 | 2250 | 3068 | 100 | 3068 | 8.03 | 0 | 0 | | 0 | 0 | 0 |
| 120 | 950 | 3509 | 8.16 | 1500 | 5540 | 100 | 5540 | 8.62 | 0 | 0 | | 0 | 0 | 0 |
| 120 | 750 | 1786 | 7.49 | 1250 | 2977 | 100 | 2977 | 8.00 | 0 | 0 | | 0 | 0 | 0 |
| 113 | 1500 | 1336 | 7.20 | 3000 | 2672 | 100 | 2672 | 7.89 | 0 | 0 | | 0 | 0 | 0 |
| 99 | 1100 | 6962 | 8.85 | 1550 | 1550 | 100 | 1550 | 7.35 | 0 | 0 | | 0 | 0 | 0 |
| 78 | 1000 | 2389 | 7.78 | 2250 | 5376 | 100 | 5376 | 8.59 | 0 | 0 | | 0 | 0 | 0 |
| 91 | 350 | 599 | 6.40 | 750 | 1284 | 88 | 1123 | 7.02 | 13 | 160 | 5.08 | 0 | 0 | 0 |
| 92 | 150 | 629 | 6.45 | 750 | 3144 | 40 | 1258 | 7.14 | 40 | 1258 | 7.14 | 0 | 0 | 0 |
| 99 | 150 | 418 | 6.04 | 750 | 2089 | 58 | 1219 | 7.11 | 42 | 870 | 6.77 | 0 | 0 | 0 |
| 82 | 100 | 150 | 5.02 | 200 | 301 | 75 | 226 | 5.42 | 25 | 75 | 4.33 | 0 | 0 | 0 |
| 92 | 450 | 1011 | 6.92 | 600 | 1348 | 100 | 1348 | 7.21 | 0 | 0 | | 0 | 0 | 0 |
| | 0 | 0 | | 500 | 1049 | 100 | 1049 | 6.96 | 0 | 0 | | 0 | 0 | 0 |
| | 0 | 0 | | 1920 | 2134 | 100 | 2134 | 7.67 | 0 | 0 | | 0 | 0 | 0 |
| 137 | 150 | 87 | 4.48 | 800 | 464 | 100 | 464 | 6.14 | 0 | 0 | | 0 | 0 | 0 |
| 78 | 950 | 554 | 6.32 | 1900 | 1108 | 100 | 1108 | 7.01 | 0 | 0 | | 0 | 0 | 0 |
| 75 | 950 | 1008 | 6.92 | 1900 | 2016 | 100 | 2016 | 7.61 | 0 | 0 | | 0 | 0 | 0 |
| 116 | 1500 | 722 | 6.58 | 2000 | 962 | 50 | 481 | 6.18 | 50 | 481 | 6.18 | 0 | 0 | 0 |
| 106 | 200 | 588 | 6.38 | 1500 | 4409 | 62 | 2713 | 7.91 | 0 | 0 | | 0 | 0 | 0 |
| 129 | 100 | 300 | 5.71 | 200 | 601 | 100 | 601 | 6.40 | 0 | 0 | | 0 | 0 | 0 |
| 113 | 100 | 196 | 5.28 | 300 | 588 | 75 | 441 | 6.09 | 25 | 147 | 5.00 | 0 | 0 | 0 |
| 153 | 500 | 1060 | 6.97 | 2500 | 5300 | 62 | 3262 | 8.09 | 38 | 2039 | 7.62 | 0 | 0 | 0 |
| 136 | 150 | 470 | 6.15 | 500 | 1566 | 100 | 1566 | 7.36 | 0 | 0 | | 0 | 0 | 0 |
| 122 | 480 | 2121 | 7.66 | 960 | 4242 | 67 | 2828 | 7.95 | 33 | 1414 | 7.25 | 0 | 0 | 0 |
| 122 | 1000 | 1151 | 7.05 | 2000 | 2303 | 60 | 1382 | 7.23 | 40 | 921 | 6.83 | 0 | 0 | 0 |
| 91 | 1200 | 3145 | 8.05 | 2400 | 2400 | 25 | 600 | 6.40 | 75 | 1800 | 7.50 | 0 | 0 | 0 |
| 115 | 800 | 2192 | 7.69 | 3200 | 3200 | 67 | 2133 | 7.67 | 33 | 1067 | 6.97 | 0 | 0 | 0 |
| 122 | 750 | 2247 | 7.72 | 1000 | 2996 | 40 | 1199 | 7.09 | 60 | 1798 | 7.49 | 0 | 0 | 0 |
| 106 | 500 | 748 | 6.62 | 1000 | 1495 | 60 | 897 | 6.80 | 40 | 598 | 6.40 | 0 | 0 | 0 |
| 91 | 10 | 14 | 2.74 | 560 | 807 | 71 | 572 | 6.35 | 29 | 235 | 5.46 | 0 | 0 | 0 |
| 77 | 100 | 78 | 4.37 | 1250 | 977 | 87 | 850 | 6.75 | 13 | 127 | 4.86 | 0 | 0 | 0 |

| LGP | apkg | ayld | Ln yield | epkg | eyld | pyld | yldr | Lnyldz | pylpd | ylpd | Lnylpz | Fym1 | Frti1 | Cpry1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 84 | 750 | 197 | 5.29 | 3500 | 919 | 85 | 785 | 6.67 | 15 | 134 | 4.90 | 0 | 0 | 0 |
| 123 | 200 | 155 | 5.05 | 4500 | 3487 | 100 | 3487 | 8.16 | 0 | 0 | | 0 | 0 | 0 |
| 84 | 1000 | 1697 | 7.44 | 2000 | 3393 | 100 | 3393 | 8.13 | 0 | 0 | | 0 | 0 | 0 |
| 143 | 1000 | 848 | 6.74 | 5000 | 4238 | 75 | 3179 | 8.06 | 25 | 1060 | 6.97 | 0 | 0 | 0 |
| 130 | 850 | 1446 | 7.28 | 1700 | 2892 | 76 | 2212 | 7.70 | 24 | 681 | 6.52 | 0 | 0 | 0 |
| 168 | 3000 | 1308 | 7.18 | 10000 | 4359 | 57 | 2491 | 7.82 | 43 | 1868 | 7.53 | 0 | 0 | 0 |
| 99 | 50 | 30 | 3.43 | 3000 | 1790 | 65 | 1162 | 7.06 | 35 | 628 | 6.44 | 0 | 0 | 0 |
| 151 | 200 | 948 | 6.86 | 400 | 1896 | 100 | 1896 | 7.55 | 0 | 0 | 0.00 | 0 | 0 | 0 |
| 158 | 600 | 901 | 6.80 | 1500 | 2253 | 44 | 1001 | 6.91 | 56 | 1252 | 7.13 | 0 | 0 | 0 |
| 144 | 150 | 560 | 6.33 | 1500 | 5604 | 80 | 4483 | 8.41 | 20 | 1121 | 7.02 | 0 | 0 | 0 |
| | 0 | 0 | | 1100 | 1251 | 100 | 1251 | 7.13 | 0 | 0 | | 0 | 0 | 0 |
| | 0 | 0 | | 750 | 598 | 100 | 598 | 6.39 | 0 | 0 | | 0 | 0 | 0 |
| 116 | 50 | 28 | 3.36 | 1800 | 1002 | 74 | 745 | 6.61 | 26 | 258 | 5.56 | 0 | 0 | 0 |
| 113 | 250 | 256 | 5.55 | 900 | 921 | 65 | 602 | 6.40 | 35 | 319 | 5.77 | 0 | 0 | 0 |
| 92 | 1200 | 5577 | 8.63 | 1500 | 1500 | 67 | 1000 | 6.91 | 33 | 500 | 6.22 | 0 | 0 | 0 |
| 85 | 400 | 995 | 6.90 | 1600 | 3979 | 50 | 1990 | 7.60 | 50 | 1990 | 7.60 | 0 | 0 | 0 |
| 160 | 500 | 282 | 5.64 | 2000 | 1127 | 67 | 752 | 6.62 | 33 | 376 | 5.93 | 0 | 0 | 0 |
| 82 | 150 | 80 | 4.39 | 2000 | 1064 | 73 | 777 | 6.66 | 27 | 288 | 5.67 | 0 | 0 | 0 |
| 92 | 1500 | 3726 | 8.22 | 3000 | 7451 | 33 | 2484 | 7.82 | 67 | 4967 | 8.51 | 0 | 0 | 0 |
| 85 | 500 | 321 | 5.77 | 3000 | 1927 | 60 | 1156 | 7.05 | 40 | 771 | 6.65 | 0 | 0 | 0 |

**APPENDIX IV: Spreadsheet of field data (Winter season 2002/2003)**

| Sl No | ID | X | Y | NoR | Sex | Vill | Ame | Aha | Lisch | Lish1 | Fld2 | Fld1 | ST | mST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 18 | 525597 | 7277793 | Cesar Vombe | m | Chibabel | 13570 | 1.36 | N | 0 | Y | 1 | sicl | H |
| 2 | 20 | 543380 | 7252282 | Nasson Cossa | m | Mao-tse-tung | 3032 | 0.30 | N | 0 | Y | 1 | scl | H |
| 3 | 33 | 551245 | 7237207 | Maria Nuvunga | f | Chicumbane | 3509 | 0.35 | N | 0 | N | 0 | ls | L |
| 4 | 34 | 553535 | 7237696 | Matilda Mungone | f | Chicumbane | 3846 | 0.38 | N | 0 | N | 0 | s | L |
| 5 | 35 | 553492 | 7237778 | Delfina Chilaule | f | Chicumbane | 3478 | 0.35 | N | 0 | N | 0 | s | L |
| 6 | 36 | 519924 | 7237386 | Almerinda Muchanga | f | Incaia | 13076 | 1.31 | N | 0 | N | 0 | ls | L |
| 7 | 39 | 535184 | 7241982 | Beauty Matavele | f | Chissano | 3261 | 0.33 | N | 0 | N | 0 | ls | L |
| 8 | 40 | 548812 | 7240024 | Henriques Bila | m | Nguleleni | 3494 | 0.35 | N | 0 | N | 0 | ls | L |
| 9 | 43 | 528200 | 7252921 | Teresinha A. Pavava | f | Olombe | 2025 | 0.20 | N | 0 | N | 0 | ls | L |
| 10 | 53 | 512394 | 7247376 | Lurdes Rafael Sitoe | f | Mazivila(ns) | 5792 | 0.58 | N | 0 | N | 0 | s | L |
| 11 | 55 | 557450 | 7275935 | Albertina Mapsanganhe | f | Canyavane | 3136 | 0.31 | N | 0 | N | 0 | s | L |
| 12 | 56 | 557047 | 7276655 | Mara Manwel Cossa | f | Canyavane | 9219 | 0.92 | N | 0 | N | 0 | ls | L |
| 13 | 57 | 557116 | 7277250 | Fenias G. Macualva | m | Canyavane | 3075 | 0.31 | N | 0 | N | 0 | ls | L |
| 14 | 58 | 557018 | 7276443 | Salome Lucas Nyoni | f | Canyavane | 3942 | 0.39 | N | 0 | N | 0 | s | L |
| 15 | 59 | 556809 | 7271794 | Teresa Ernesto Sive | f | Mudada | 3284 | 0.33 | N | 0 | N | 0 | s | L |
| 16 | 60 | 555991 | 7270964 | Lucia Sitoe | f | Mudada | 1905 | 0.19 | N | 0 | N | 0 | ls | L |
| 17 | 61 | 556010 | 7270888 | Lucrencia A. Tovela | f | Mudada | 5567 | 0.56 | N | 0 | N | 0 | ls | L |
| 18 | 62 | 556550 | 7271006 | Teresinha Cuna | f | Mudada | 2233 | 0.22 | N | 0 | N | 0 | ls | L |
| 19 | 72 | 539847 | 7269596 | Aurelio Hlaveya | m | Mucotoene | 7765 | 0.78 | N | 0 | N | 0 | sic | H |
| 20 | 73 | 539337 | 7269040 | Aurelio Hlaveya | m | Mucotoene | 11634 | 1.16 | N | 0 | N | 0 | sil | M |
| 21 | 74 | 539060 | 7269242 | Henriqueta Mulambu | f | Mucotoene | 10797 | 1.08 | N | 0 | N | 0 | sicl | H |
| 22 | 75 | 539402 | 7269248 | Luis Macuacua | m | Mucotoene | 11686 | 1.17 | N | 0 | N | 0 | sil | M |
| 23 | 77 | 529087 | 7270990 | Lucia Betuel Tivane | f | Chaimite | 4884 | 0.49 | N | 0 | Y | 1 | sicl | H |
| 24 | 78 | 528983 | 7270320 | Natael Alberto Tivane | f | Chaimite | 10698 | 1.07 | N | 0 | Y | 1 | sicl | H |
| 25 | 79 | 530810 | 7276428 | Bidas Tive | f | Mohambe | 9784 | 0.98 | N | 0 | N | 0 | sil | M |
| 26 | 85 | 531043 | 7278853 | Antonio Muiocho | m | Gomba-Tlatlene | 4799 | 0.48 | N | 0 | Y | 1 | sil | M |
| 27 | 86 | 525772 | 7279721 | Pedro Jose Ussivane | m | Chibabel | 998 | 0.10 | N | 0 | N | 0 | s | L |

| Sl No | L | M | H | SpH | pbp1 | 1pbp | pbpu | pbpu1 | p1daj | pltd | ptdaj | ptdpl | pltpu | pltpu1 | pltm | pltm1 | Nosh |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 6.5 | 37385 | 1 | animal | 1 | 128 | 37409 | 152 | 24 | manual | 0 | hill | 0 | 4 |
| 2 | 0 | 0 | 1 | 6.5 | 37324 | 1 | animal | 1 | 67 | 37356 | 99 | 32 | animal | 1 | line | 1 | 3 |
| 3 | 1 | 0 | 0 | 6.5 | 37324 | 1 | manual | 0 | 67 | 37355 | 98 | 31 | manual | 0 | hill | 0 | 4 |
| 4 | 1 | 0 | 0 | 6.5 | 37324 | 1 | manual | 0 | 67 | 37355 | 98 | 31 | manual | 0 | hill | 0 | 4 |
| 5 | 1 | 0 | 0 | 6.5 | 37317 | 1 | manual | 0 | 60 | 37348 | 91 | 31 | manual | 0 | hill | 0 | 4 |
| 6 | 1 | 0 | 0 | 6 | 37324 | 1 | manual | 0 | 67 | 37348 | 91 | 24 | manual | 0 | hill | 0 | 3 |
| 7 | 1 | 0 | 0 | 6 | 37317 | 1 | manual | 0 | 60 | 37355 | 98 | 38 | manual | 0 | hill | 0 | 3 |
| 8 | 1 | 0 | 0 | 5.5 | 37317 | 1 | manual | 0 | 60 | 37356 | 99 | 39 | manual | 0 | hill | 0 | 3 |
| 9 | 1 | 0 | 0 | 6.5 | 37317 | 1 | manual | 0 | 60 | 37369 | 112 | 52 | manual | 0 | hill | 0 | 4 |
| 10 | 1 | 0 | 0 | 6 | 37317 | 1 | manual | 0 | 60 | 37348 | 91 | 31 | manual | 0 | hill | 0 | 2 |
| 11 | 1 | 0 | 0 | 5.5 | 37317 | 1 | manual | 0 | 60 | 37348 | 91 | 31 | manual | 0 | hill | 0 | 4 |
| 12 | 1 | 0 | 0 | 6 | 37317 | 1 | manual | 0 | 60 | 37348 | 91 | 31 | manual | 0 | hill | 0 | 4 |
| 13 | 1 | 0 | 0 | 6 | 37317 | 1 | animal | 1 | 60 | 37348 | 91 | 31 | animal | 1 | line | 1 | 3 |
| 14 | 1 | 0 | 0 | 5.5 | 37317 | 1 | manual | 0 | 60 | 37348 | 91 | 31 | manual | 0 | hill | 0 | 4 |
| 15 | 1 | 0 | 0 | 6 | 37338 | 1 | manual | 0 | 81 | 37348 | 91 | 10 | manual | 0 | hill | 0 | 4 |
| 16 | 1 | 0 | 0 | 6.5 | 37324 | 1 | manual | 0 | 67 | 37355 | 98 | 31 | manual | 0 | hill | 0 | 4 |
| 17 | 1 | 0 | 0 | 6 | 37296 | 1 | manual | 0 | 39 | 37355 | 98 | 59 | manual | 0 | hill | 0 | 4 |
| 18 | 1 | 0 | 0 | 6 | 37317 | 1 | manual | 0 | 60 | 37348 | 91 | 31 | manual | 0 | hill | 0 | 4 |
| 19 | 0 | 0 | 1 | 6 | 37668 | 1 | animal | 1 | 46 | 37696 | 74 | 28 | animal | 1 | line | 1 | 4 |
| 20 | 0 | 1 | 0 | 6 | 37613 | 1 | animal | 1 | 356 | 37668 | 46 | 55 | animal | 1 | line | 1 | 3 |
| 21 | 0 | 0 | 1 | 7 | 37637 | 0 | animal | 1 |  | 37637 | 15 | 0 | animal | 1 | line | 1 | 4 |
| 22 | 0 | 1 | 0 | 6.8 | 37654 | 1 | animal | 1 | 32 | 37713 | 91 | 59 | animal | 1 | line | 1 | 3 |
| 23 | 0 | 0 | 1 | 6.8 | 37272 | 1 | manual | 0 | 15 | 37416 | 159 | 144 | manual | 0 | hill | 0 | 4 |
| 24 | 0 | 0 | 1 | 6.9 | 37362 | 1 | manual | 0 | 105 | 37423 | 166 | 61 | manual | 0 | hill | 0 | 2 |
| 25 | 0 | 1 | 0 | 6.8 | 37258 | 1 | animal | 1 | 1 | 37303 | 46 | 45 | animal | 1 | line | 1 | 2 |
| 26 | 0 | 1 | 0 | 7 | 37569 | 1 | animal | 1 | 312 | 37661 | 39 | 92 | animal | 1 | line | 1 | 3 |
| 27 | 1 | 0 | 0 | 6 | 37338 | 1 | manual | 0 | 81 | 37362 | 105 | 24 | manual | 0 | hill | 0 | 3 |

| Sl No | spg | phph | vu | vu1 | Thng | Thng1 | wedg | Tw | wdg1 | w1dap | wdg2 | w2dap | wdpu | Hrvtd | hdaj1 | LGP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 80 | 15625 | Lo | 1 | N | 0 | Once | 0 | 37452 | 43 | | | mu | 37491 | 234 | 82 |
| 2 | 70 | 20408 | Lo | 1 | Y | 1 | Once | 0 | 37399 | 43 | | | mu | | | |
| 3 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37385 | 30 | 37423 | 68 | mu | 37484 | 227 | 129 |
| 4 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37378 | 23 | 37409 | 54 | mu | 37484 | 227 | 129 |
| 5 | 100 | 10000 | Lo | 1 | Y | 1 | Once | 0 | 37385 | 37 | | | mu | 37491 | 234 | 143 |
| 6 | 100 | 10000 | Lo | 1 | Y | 1 | Once | 0 | 37409 | 61 | | | mu | 37470 | 213 | 122 |
| 7 | 100 | 10000 | Lo | 1 | N | 0 | Twice | 1 | 37385 | 30 | 37416 | 61 | mu | 37501 | 244 | 146 |
| 8 | 100 | 10000 | Lo | 1 | Y | 1 | Once | 0 | 37416 | 60 | | | mu | 37501 | 244 | 145 |
| 9 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37409 | 40 | 37439 | 70 | mu | 37508 | 251 | 139 |
| 10 | 100 | 10000 | Lo | 1 | N | 0 | Twice | 1 | 37409 | 61 | 37446 | 98 | mu | 37470 | 213 | 122 |
| 11 | 120 | 6944 | Lo | 1 | Y | 1 | Twice | 1 | 37378 | 30 | 37409 | 61 | mu | 37470 | 213 | 122 |
| 12 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37378 | 30 | 37416 | 68 | mu | 37484 | 227 | 136 |
| 13 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37369 | 21 | 37416 | 68 | mu | 37484 | 227 | 136 |
| 14 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37399 | 51 | 37409 | 61 | mu | 37477 | 220 | 129 |
| 15 | 110 | 8264 | Lo | 1 | Y | 1 | Twice | 1 | 37378 | 30 | 37430 | 82 | mu | 37501 | 244 | 153 |
| 16 | 100 | 10000 | Lo | 1 | Y | 1 | Once | 0 | 37392 | 37 | | | mu | 37515 | 258 | 160 |
| 17 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37385 | 30 | 37409 | 54 | mu | 37515 | 258 | 160 |
| 18 | 70 | 20408 | Lo | 1 | Y | 1 | Twice | 1 | 37409 | 61 | 37470 | 122 | mu | 37508 | 251 | 160 |
| 19 | 90 | 12346 | Lo | 1 | Y | 1 | Twice | 1 | 37713 | 17 | 37734 | 38 | mu | 37811 | 189 | 115 |
| 20 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37689 | 21 | 37696 | 28 | mu | 37795 | 173 | 127 |
| 21 | 80 | 15625 | Lo | 1 | Y | 1 | Once | 0 | 37689 | 52 | | | mu | 37727 | 470 | 90 |
| 22 | 40 | 62500 | Lo | 1 | Y | 1 | Twice | 1 | 37734 | 21 | 37757 | 44 | mu | 37849 | 227 | 136 |
| 23 | 100 | 10000 | Lo | 1 | Y | 1 | Twice | 1 | 37453 | 37 | 37491 | 75 | mu | 37538 | 281 | 122 |
| 24 | 80 | 15625 | Lo | 1 | N | 0 | Twice | 1 | 37446 | 23 | 37460 | 37 | mu | 37538 | 281 | 115 |
| 25 | 90 | 12346 | Lo | 1 | N | 0 | Once | 0 | 37324 | 21 | | | mu | 37392 | 135 | 89 |
| 26 | 120 | 6944 | Lo | 1 | Y | 1 | Twice | 1 | 37689 | 28 | 37703 | 42 | mu | 37757 | 135 | 82 |
| 27 | 70 | 20408 | Lo | 1 | Y | 1 | Twice | 1 | 37416 | 54 | 37470 | 108 | mu | 37522 | 265 | 160 |

| Sl No | apkg | ayld | Ln yield | epkg | eyld | pyld | yldr | lnyldz | pylpd | ylpd | Lnylpz | fym1 | Frti1 | Cpry1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 50 | 37 | 4 | 1200 | 884 | 100 | 884 | 6.8 | 0 | 0.0 | | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 250 | 825 | 0 | 0 | | 0 | 0.0 | | 0 | 0 | 0 |
| 3 | 250 | 712 | 7 | 1000 | 2850 | 73 | 2090 | 7.6 | 27 | 759.9 | 6.6 | 0 | 0 | 0 |
| 4 | 100 | 260 | 6 | 250 | 650 | 50 | 325 | 5.8 | 50 | 325.0 | 5.8 | 0 | 0 | 0 |
| 5 | 10 | 29 | 3 | 500 | 1438 | 100 | 1438 | 7.3 | 0 | 0.0 | | 0 | 0 | 0 |
| 6 | 250 | 191 | 5 | 750 | 574 | 50 | 287 | 5.7 | 40 | 229.4 | 5.4 | 0 | 0 | 0 |
| 7 | 100 | 307 | 6 | 1000 | 3066 | 100 | 3066 | 8.0 | 0 | 0.0 | | 0 | 0 | 0 |
| 8 | 300 | 859 | 7 | 500 | 1431 | 100 | 1431 | 7.3 | 0 | 0.0 | | 0 | 0 | 0 |
| 9 | 100 | 494 | 6 | 750 | 3704 | 100 | 3704 | 8.2 | 0 | 0.0 | | 0 | 0 | 0 |
| 10 | 750 | 1295 | 7 | 1500 | 2590 | 67 | 1727 | 7.5 | 33 | 863.3 | 6.8 | 0 | 0 | 0 |
| 11 | 10 | 32 | 3 | 250 | 797 | 58 | 465 | 6.1 | 42 | 332.2 | 5.8 | 0 | 0 | 0 |
| 12 | 20 | 22 | 3 | 400 | 434 | 58 | 251 | 5.5 | 42 | 182.7 | 5.2 | 0 | 0 | 0 |
| 13 | 300 | 976 | 7 | 1000 | 3252 | 71 | 2323 | 7.8 | 29 | 929.2 | 6.8 | 0 | 0 | 0 |
| 14 | 15 | 38 | 4 | 60 | 152 | 82 | 125 | 4.8 | 18 | 27.1 | 3.3 | 0 | 0 | 0 |
| 15 | 50 | 152 | 5 | 150 | 457 | 50 | 228 | 5.4 | 50 | 228.4 | 5.4 | 0 | 0 | 0 |
| 16 | 50 | 262 | 6 | 250 | 1312 | 63 | 820 | 6.7 | 38 | 492.1 | 6.2 | 0 | 0 | 0 |
| 17 | 100 | 180 | 5 | 300 | 539 | 63 | 337 | 5.8 | 38 | 202.1 | 5.3 | 0 | 0 | 0 |
| 18 | 50 | 224 | 5 | 200 | 896 | 67 | 597 | 6.4 | 33 | 298.5 | 5.7 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 750 | 966 | 100 | 966 | 6.9 | 0 | 0.0 | | 0 | 0 | 0 |
| 20 | 500 | 430 | 6 | 2000 | 1719 | 67 | 1146 | 7.0 | 33 | 573.0 | 6.4 | 0 | 0 | 0 |
| 21 | 500 | 463 | 6 | 2250 | 2084 | 71 | 1488 | 7.3 | 29 | 595.4 | 6.4 | 0 | 0 | 0 |
| 22 | 600 | 513 | 6 | 1250 | 1070 | 54 | 576 | 6.4 | 46 | 493.7 | 6.2 | 0 | 0 | 0 |
| 23 | 1000 | 2048 | 8 | 2000 | 4095 | 50 | 2048 | 7.6 | 50 | 2047.7 | 7.6 | 0 | 0 | 0 |
| 24 | 1600 | 1496 | 7 | 2250 | 2103 | 62 | 1294 | 7.2 | 38 | 808.9 | 6.7 | 0 | 0 | 0 |
| 25 | 4000 | 4088 | 8 | 6000 | 6133 | 63 | 3833 | 8.3 | 38 | 2299.7 | 7.7 | 0 | 0 | 0 |
| 26 | 300 | 625 | 6 | 2000 | 4167 | 100 | 4167 | 8.3 | 0 | 0.0 | | 0 | 0 | 0 |
| 27 | 100 | 1002 | 7 | 500 | 5012 | 67 | 3341 | 8.1 | 33 | 1670.6 | 7.4 | 0 | 0 | 0 |