Draft

# Synthesis of Information on Sugar Beet Cultivation in Kenya

**For**

**AmBeet Co. Ltd**

**P.O. Box**

**Tel:**

Prepared by

Dr. Joseph M. Maitima PhD
Ecodym Africa Consultants
P. O. Box 50901 -200 Nairobi
Tel: +254 733 255 739
Email: j.maitima@ecodymafrica.co.ke
Web: www.ecodymafrica.co.ke

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# Introduction

Fodder and red beets (table beets) have been cultivated in Kenya for a long time following their introduction by white settlers who grew them as fodder for their livestock and the red beets for their domestic use. Since the introduction of the fodder beet (same species as sugar beet – *beta vulgaris*) several decades ago, a number of farmers in Nyandarua adopted the production and to date a number still produce the crop. The cultivation however, has been only at a small scale.

In other parts of the world the Sugar Beet is an industrial crop grown for commercial production of Sugar. In Europe and America Sugar Beet is the main source of sugar and worldwide Sugar Beet contributes to over 30% of Sugar consumed.

While Sugar Beet is a temperate crop suitable for cultivation only in the cold weather of the temperate regions, varieties suitable for the tropics called *Tropical Sugar beet* (TSB) were produced by Syngenta as they can withstand the hot climates of tropical countries. Following the development of these varieties that have a number of genotypes (represented by several seed types), countries in warm climates like India, Bangladesh and Pakistan have been cultivating the crop for a number of years and have developed sugar processing industries that extracts sugar from Tropical Sugar Beet. In Africa a number of countries produce sugar beets and have variable capacities for processing into sugar. These include South Africa, Egypt and Nigeria. Production of sugar from TSB has many advantages compared to sugar cane based production.

In Kenya several trials have been made by various groups to test the agronomics of TSB cultivation and results have been very successful. These trials have been on experimental basis based on small plots to test mainly the viability of cultivating the crop in Kenyan soils and climatic conditions. Results of these experiments have been overwhelmingly encouraging with results very similar to those in other countries where production has already been commercialised.

Ecodym Africa Ltd has been contracted by AmBeet Ltd to consolidate all the results of experimentation done so far and pilot a commercial production venture prior to engaging in a full large scale Tropical Sugar Beet farming and commercial production of sugar. The area agreed to base this piloting crop is Ol Kalau Sub County in Nyandarua County. The objectives for the piloting are:

a. To test production of TSB on large scale in Kenya
b. Test best land management practices suitable for large scale TSB production
c. Make recommendation on how to manage labour, farm machineries, weeding and harvesting of sugar beet
d. Develop best protocols and pilot strategies for identifying and managing pests and diseases if and when they occur.

e. Test value addition processing for the industrial b- products into commercially viable and marketable products like animal feeds
f. Develop crop irrigation strategies for use when rainfall is insufficient

## Purpose for this synthesis

A number of experiments on the agronomy and economic potentials of TSB production have been made for more than 20 years in Kenya to provide preliminarily information on the cultivation and commercial production. Several reports on TSB cultivation potential in Kenya, and results of some trials have been made. In order for someone to benefit from the knowledge acquired so far, it is important to synthesize all available information into one document that can be used as a single source of information and for reference during cultivation.

It is necessary to pilot the production at small scale level the full production of TSB before embarking on large scale production in order to optimize and justify heavy investments of large scale production and establishments of processing industry. Generally a pilot project is usually an initial small - scale implementation of an activity that can be used to prove the viability of a project idea. This could involve either the exploration of a novel new approach or idea or the application of a standard approach recommended towards achieving a certain goal. An example of this would be the standard implementation approach for a new off-the - shelf package like the results of experiments done on TSB cultivation in Kenya and the commercial extraction of sugar.

Typically deliverables in the pilot project proposed here will include:

- Robust lessons learned, risks and issues logs
- Benefits assessment
- Viability report and recommendations
- Route map for implementation
- Revised investment appraisal and project plan

This synthesis is intended to inform AmBeet Company in the proposed piloting and large scale production of sugar beet in Nyandarua and Narok Counties. The piloting is planned to lead to large scale production in the following year as an up scaling process.

## Options for TSB production in Nyandarua

The amounts of sugar beet required to run factory are large in order for the factory operate profitably. Studies show that a medium size factory will require a minimum of 500 tonnes of sugar beet per day.

There are two growing seasons in Nyandarua and the maturity of TSB is 6 months maximum. A crop harvested should be able to feed the factory for up to six months before the other crop matures. Leaving about 1 month for factory switchover to the next crop the harvested sugar beets must feed the factory for at least 5 moths.

A factory processing 500 tonnes of sugar beet per day will require about 12,000 tonnes per month assuming a 6 working days per week and 60,000 tonnes of sugar beet pre season and over 120,000 tonnes of sugar beet per year in 10 month factory operation year.

According to trials made in Nyandarua 1 hectare produces about 60 tonnes of sugar beet per season. To feed a that processes 500 tonnes of beet per day or 60,000 tonnes of beet per growing season will therefore require a beet production area of over 1,000 hectares or well over 2,000 acres of sugar beet production per season.

For a company to produce its own sugar beet to feed a factory rated at processing 500 tonnes of raw sugar beet per day will require to manage a land production area of at least 2,000 acres for every season. For a crop rotation of 4 seasons before re planting of sugar beet on the same land the company will require about 8,000 acres of production area divided into 4 paddocks of 2,000 acres each.

Managing an 8,000 acres farm is an uphill task especially for a company whose main task is not to grow by to process sugar from sugar beet. Such large production would turn the company into an agricultural production company rather than a sugar manufacturing company.

## Contract farming

An alternative to putting too much energy into agricultural production will be contract farmers to do the sugar beet production while the company concentrates on processing the sugar beet into sugar. Contract farming will require farmer training on sugar beet production procedures including the need for rotation.

In addition to farmer training contract farming will require careful legal arrangement between the contractor (the company) and the contracted (the farmers) and the agreements made monitored closely under set down rules and regulations between the two parties.

More realistic contract farming is to engage farmers to a minimum acreage of production per farmer where each production unit should be not less than 20 acres or more for example. Dealing with very small acreages will increase the cost of production per acre, cost of monitoring, transportation and also risk having farmers who may not follow the standards of production adequately.

Contract farming is thought to be more beneficial to the local communities as it will involve them in production in their own farms rather than be employees on the company farm. This will require the contracting company to have a very effective monitoring procedure to amke sure rules and regulations are followed.

## Combined own and contract farmer production

A combination of own production and contract farming would also work especially when large processing is done. Such an alternative can be useful to make sure that some of the sugar beet (those produced by the company) have high quality sugar beets that produce high quality sugar.

## Baseline Studies

Literature shows that fodder beets and red table beets have been cultivated in Nyadarua for many years mainly as fodder for animals and also for human consumption as in the case for the red table beets. Tropical Sugar Beet (TSB) a variety developed by Syngenta for cultivation in the tropics was formally put on experimental trials in Nyandarua county in 1996 by Kiriita agricultural self help group with a purpose of understanding the agronomics of the variety in Kenya so as to expand the cultivation of the crop variety in Kenya and explore the potential for commercial on farm production and subsequently producing sugar both for local consumption and for export. These initiatives were supported by Syngenta and the government of Turkey who provided the seeds and offered a postgraduate training on the cultivation of TSB for Kenyan.

Recently AmBeet privately registered company developed interest in cultivating the crop in Kenya. The initial phase was to produce about 500 tonnes per day (tpd) in Nyandarua and establish a capacity of producing about 12,000 tonnes of white Sugar per annum. Following the success of the implementation of the first phase, it was planned to scale out to other parts of Nyandarua and build several small factories around the county, each of which will collect sugar beets from a radius of 10 Km to reduce the cost of transportation.

AmBeet has conducted experimental trials on their own both to understand sugar beet production procedures and to add on to the existing knowledge from farmer's experimentation in Nyandarua.

By the year 2007, 14 TSB varieties had been tested in 4 ecological zones of Nyandarua County. Reports show that as small scale production continued, farmers used to process TSB manually to extract sugar, molasses, and pulp. Both molasses and pulp are used as animal feed while sugar is consumed locally by people. Leaves are fed to animals directly as animal feed. Despite having been tested for over 20 years, Sugar Beet is not listed among the crops produced in the county in the Nyandarua ICDP (Integrated County Development Plan) of 2013, meaning that the production of the crop has not increased substantially. Discussions with farmers in Nyandarua show that the reason why cultivation has not picked in the area is lack of market for the sugar beets. Lack of a market to sell the produce has discouraged the farmers n production of TSB.

Data and information relating to sugar beet cultivation in Nyandarua and Narok will be sort from websites of various state agencies and repository centers. All the information to be presented in this synthesis will be obtained from literature and all sources will be referenced appropriately. Information from unpublished materials and discussions with key informants that will finally appear in the report will be acknowledged accordingly. To fill up some of the gaps from the literature, the consultant will seek information from respective institutions as

much as it will be needed and available. We propose to seek data from the following national and private institutions either by way of downloading from websites or by formal visits to the relevant departments of each institution:

**Table 1 List of Institutions to be consulted for specific information**

| | | |
|---|---|---|
| 1. | **KALRO**<br>Kenya Agricultural and Livestock Research organization | Soil analysis; advice on soil sampling for plant nutrient analysis. |
| 2. | **KMD**<br>Kenya Meteorological Department | On weather data, Rainfall patterns and seasonality |
| 3. | **WARMA**<br>Water Resources Management Authority | Irrigation water abstraction; permits and water use rights |
| 4. | **NIB**<br>National Irrigation Board | Best irrigation methods if indeed irrigation will be needed |
| 5. | **Syngenta**<br>International Seed Company | Source of seeds, updates on variety improvements |
| 6. | KOAN | Organic production and certification as an organic product for overseas premium markets |
| 7. | ICIPE<br>International Centre for Insect Physiology and Ecology | Integrated Pest Management (IPM) best non-insecticide pest control for sugar beet |
| 8. | KSA<br>Kenya Sugar Authority | Participation in the national sugar sector / industry |
| 9. | Nyandarua County Government | Agriculture docket Nyandarua County ; Nynadarua CIDP |
| 10. | Narok County Government | Agriculture docket Narok Count, Narok CIDP |

| | | |
|---|---|---|
| 11. | Sugar beet farmers association | Geita farmers, Nyandarua Sugar Beet farmers Association |
| 12. | Key Informants | Individuals with key information on cultivation of TSB |

As much as it will be possible we will rely on published information.

# General Information on Cultivation of TSB

Under tropical conditions sugar beet is an intensive crop requiring considerable amounts of inputs and knowledge. Sugar beet is a rotational crop grown in the same field after several seasons of planting other crops like legumes, cereals, and possibly an oil crop to help in replenishing nutrients needed by sugar beet and to reduce on inputs like chemical fertilizer. Among other the benefits of crop rotation are better soil nutrient management, reduced pest and disease infestation, and quality produce due to less use of insecticides. This section outlines activities proposed for the piloting of commercial cultivation of sugar beet.

## Land Preparation

Sugar Beet being a root crop requires deep ploughing (45 cm deep) followed by harrowing to obtain a good soil condition for favourable seed germination and tuber development. After proper levelling is done, furrows and ridges are developed 50 cm apart to ensure adequate drainage in case of heavy rains that may cause flooding. Land preparation could be mechanised to reduce dependence on human labour that could be either too costly or unavailable when needed. Land preparation should be done in good time during the dry season prior to the onset of rains and in time to allow planting before the rains.

## Fertilizer applications

A single application of mineral NPK (default rate: 120:75:75 Kg/ha) 1 or 2 weeks before sowing is needed. Soil fertility tests should be done to assess the need for interventions on fertilizer applications. N can also be applied as organic manure earlier in the season. There is no need to apply N after canopy has closed: the tap root is very efficient and can pump N from deep in the ground until late in the season. There is no need to apply too much N as it can lower sugar content and also lower extractability and not improve white sugar yield.

In case of fertilizer the following application has been found effective based on soil the conditions. Soil analysis will help to determine nutrient deficiencies in the soil and the levels of manure and fertilizer applications required. In the field trials by Kiriita farmers in Nyandarua, well decomposed manure was applied in all plots except one. Fertilizer 20:20:0 was applied in all plots at a rate of 5gm/hole. Some plots were broadcasted with fertilizer and manure then mixed thoroughly with soil.

**Table 2 Possible Manure and Fertilizer application**

| Manure and Fertilizer | Basal Application | Top Dressing |
|---|---|---|
| Farm Yard Manure | 10 tonnes per acre | |
| Bio fertilizer<br>Azospirillum<br>Phosphobacteria | <br>2 kg / acre (10 packets)<br>2 kg / acre (10 packets) | <br>-<br>- |
| Fertilizers<br>Nitrogen<br>Phosphorus<br>Potassium | <br>30 Kg / per acre<br>24 Kg / per acre<br>25 Kg / per acre | <br>15 Kg per acre each at 30 and 60 Days |

## Seed variety selection

There are a number of TSB seed varieties available from Syngenta. The seeds that were tested in Nyandarua and their yields per hectare are listed in the table below. It is important to buy fresh seeds of known source and variety for every planting. There is a need to make prior arrangements with the seed company so as to have the needed seed varieties in the required amounts and at the right time. Seeds found to be suitable for Nyandarua based on the experimentation done are; Penta, Monodoro and Inger.

Before settling on a particular variety it will be recommendable to discuss with the seed company and farmers in Nyandarua to get their experiences on the performance of different varieties

**Table 3 Sugar Beet varieties tested in Nyandarua**

| Test Code | Name of Variety | Yield per hectare |
|---|---|---|
| K1 | H66199 | - |
| K2 | SICURA | - |
| K3 | PENTA | 81.9 |
| K4 | MONODORO | 97.13 |
| K5 | INGER | 71.8 |
| K6 | POSADA | 94.4 |
| K7 | 410141 | 96.9 |
| K8 | TOMBA | 100.2 |
| K9 | MONZA | 121.2 |

## Planting

In rainfed cultivation Sugar beet is best planted at the beginning of the rainy season. Ideal planting time depends on the climate of the region. Appropriate sowing window will have to combine warm temperatures on well drained soil followed by mild rains. To obtain a plant population of about 40,000 plants / acre use 2 packets designer seed each containing about 20,000 seeds and weighing 600g. The recommended spacing is 50x20 cm. The seeds are dipped 2 cm deep on the top of the ridges and 20 cm apart and one seed per hole. Some literature suggests an interval of 50 cm between rows and 16-17 cm between plants to have a density of 42,000 plants per acre. TSB is a monogerm: a single plant comes out of one seed, therefore no need for thinning. Experiences by Geita farmers was the seed germination occurred at 7 – 10 days after planting. Germination was well over 90% and 100% in most sites and for all varieties, but the plot where manure was not applies seed germination was at a lower rate of 40 – 90%. This shows that soil fertility and retention of soil moisture content do influence germination sugar beet seeds.

In Nyandarua, farmers experience indicates a preference for planting sugar beet during the April rains due to more reliable rains although October rains are also good. Rain during October is less reliable.

## Weed control

Weed control in Sugar Beet is a very intensive operation especially during the early part of the season. The crop should be maintained weed free up to 75 days after sowing. To control weeds, herbicides e.g., Pendimethalin at 1.5 lit per acre can be dissolved in 300 liters if water and sprayed by hand operated sprayer on 3$^{rd}$ day after sowing, followed by hand weeding on the 25$^{th}$ and 50$^{th}$ day after sowing. In small scale operations like during the pilot phase weeding can be done by human labour but in large scale production weeding can be done mechanically by use of appropriate machineries like tractors or hand tractors.

## Crop water requirements and irrigation

Sugar beet is very sensitive to water stagnation at all times of its growth. Irrigation should be assessed and applied based on soil type and climatic conditions. Planting should be done when soils are wet. If no rain at the time of sowing, wetting the soil through irrigation prior to planting is necessary because sufficient soil moisture at sowing time is a pre-requisite for proper germination. If the soil temperatures are above 35$^0$C and dry, irrigation prior to sowing is necessary. Light and frequent irrigation is necessary about 5 to 7 days for light textured sandy loam soils and 8 to 10 days for heavy textured loam soils. It is necessary to maintain soil moisture until emergence is completed. After emergence irrigation is required every 10 to 15 days depending on the evolution of soil moisture and rainfalls. Irrigation stops at least 2 weeks before harvesting. At the time of harvest if the soil is dry and hard it is necessary to irrigate for easy harvest.

## Plant Healthcare

The major insect pests affecting TSB are aphids, tobacco caterpiller, and diamond backmoth. Integrated Pest Management has to be applied to control these pests. Aphids can be controlled by spraying with 3% Neem oil or dimethoate 2 ml/lit with teepol 0.5 ml/lit for tobacco caterpiller spray with endosulfon 2ml/lit or carbaryl 2g / lit of water.

The major diseases that affect sugar beet are rhizoctonia wilt, powdery wilt, cercospora leaf spot, and fusarium yellow. To control rhizosctonia wilt, spot drenching with Bordeaux 1 % and fusarium wilt, and for fusarium yellow of wettable powder at 3% and for cercospora lead spot, application of mancozeb 0.25% on 10 – 14 day schedule.

Powdery Mildew and cercospora are two leaf diseases found almost everywhere and do affect TSB. Ideally a foliar spray with an appropriate is strongly advised when first symptoms appear.

## Harvesting

TSB crop matures in 5 to 6 months. Sugar beet has no ripening stage and if well maintained the crop can grow almost indefinitely. The yellowing of lower leaf whirls of plants indicate maturity of beet tuber ready for harvest. The tuber should be pulled out gently to avoid breakage, and the beet tuber should be handled as gently as possible to remove the soil and

trash to minimize bruising the tuber.  In practice harvesting can be done after 4, 5 and 6 months after sowing

Harvesting should be timed so that the tubers can reach the processing factory within 48 for processing. Till this time the tubers must be maintained in the field.

All the seeds tested in Nyandarua had good yields. The yields varied from Penta, Monodoro, Inger, H66199 to Sicura in the order of highest to lowest. However, yields for Monodoro were lower than Penta due to poor germination. Yields from Penta were the best in overall valuation at Farmers Training Centre (FTC).

Three out the five seed varieties tested (Penta, Monodoro, and Inger) were from Syngenta AB while two (H66199 and Sicura) were from Vanderhave.

# Baseline Scenarios in Nyandarua

Nyadarua County lies along the western slopes of Aberdare ranges (also referred to Nyandarua ranges). The county strands along the entire stretch of the ranges and extends northwards to the ridges of the eastern Rift Valley to border with Nakuru along the escarpment. Nyadarua carries all river channels draining the eastern part of Aberdare ranges. Rivers drain into the rift Valley, the main one being River Malewa to flows into Lake Naivasha.

Tha main economic activity in Nyandarua is agriculture producing a number of crops such as Irish Potatoes, Wheat, Maize, Peas, cabbages, and carrots. Dairy production is also practiced to a large extent by many farmers in small scale production units but a few farmers have large scale production units.

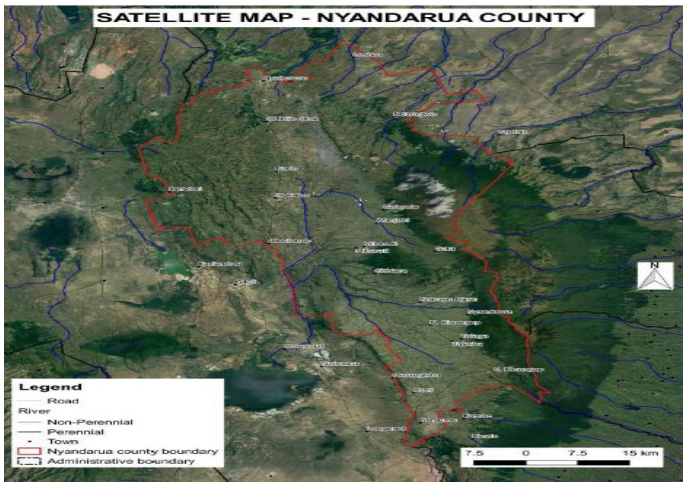



**Figure 1  Satellite map of Nyandarua County**

## Climate and agro ecological zones of Nyandarua County

Administratively Nyandarua County has been divided into five sub- counties and ecologically into more than 10 transecting agro -ecological zones. Sugar beet has been tested in 4 Agro-

ecological zones UH1 UH2, UH 3 and UH4 all of which are found in Ndaragua and Ol Jorok sub counties.

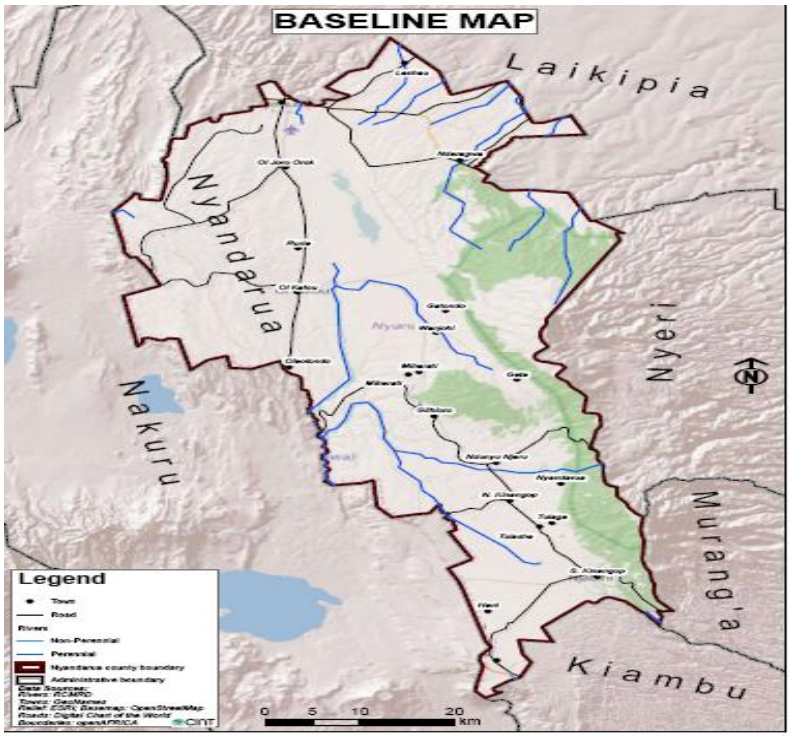
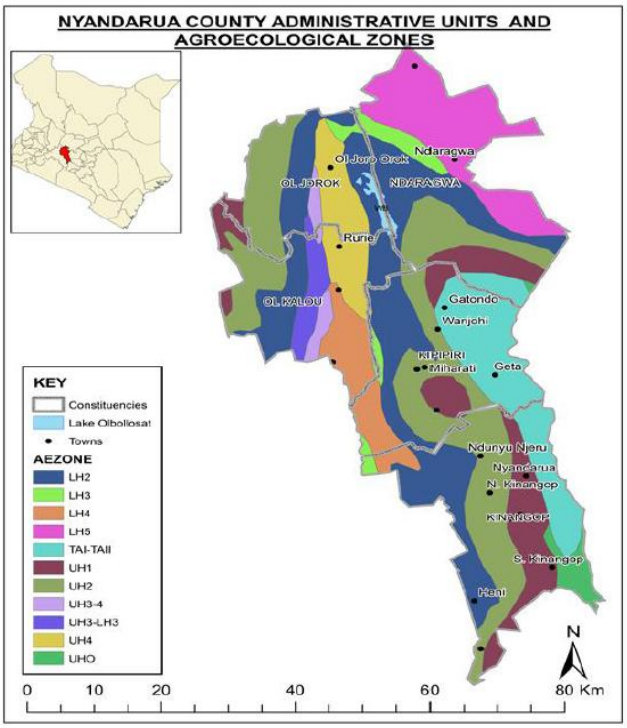



**Figure 2 Base map of Nyandarua County Showing major roads and rivers**

A major road runs along the county from the border with Kiambu County to the border with Laikipia County on the north eastern end of the county. Several other roads network link county to the town in the Rift Valley like Naivasha, Gilgil and Nakuru. The county is also linked to Thika town through a road from Kinangop to Thika. The county is also connected to Nyeri county by a road through Mweiga.

The county is therefore well networked to major towns where farmers can take their crops to market centers and also from where they can get farm inputs and household goods.

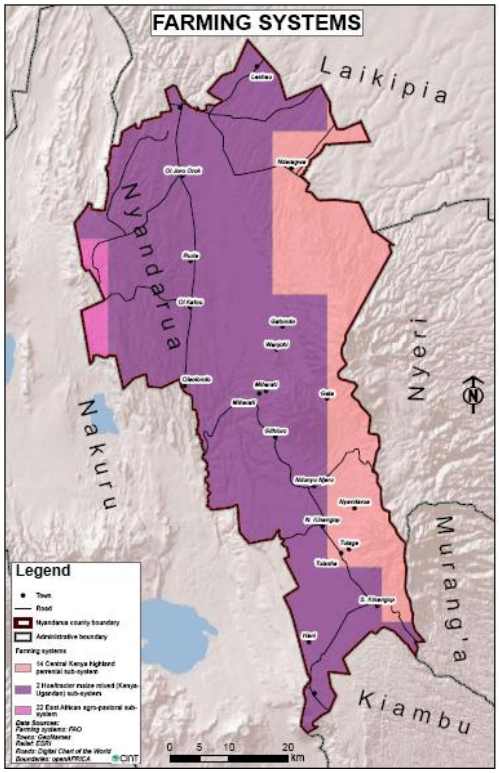
**Figure 3 Agro - Ecological Zones (AEZ) of Nyandarua County**



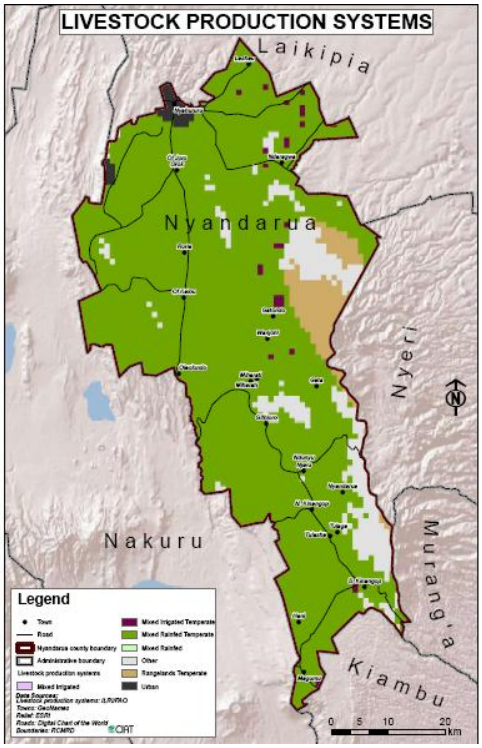

**Agro Ecological Zones** (AEZs) are geographical areas exhibiting similar climatic conditions that determine their ability to support rainfed agriculture. At a regional scale, AEZs are influenced by latitude, elevation, and temperature, as well as seasonality, and rainfall amounts and distribution during the growing season.

All agro ecological zones have been defined based on the types of vegetation found in the area and the type of crops that do best. The typical agro- ecological zones where TSB is grown in Nyandarua are those found in Ndaragua and Ol Jorok Sub Counties which include the Upper and Lower Highlands zones of UH 3, UH4 LH 2, LH 3 and LH4 as shown in fig.3. However, most of Nyandarua has been assessed to range from good to fair for TSB cultivation with only a small portion thought to be bad. (fig 5).

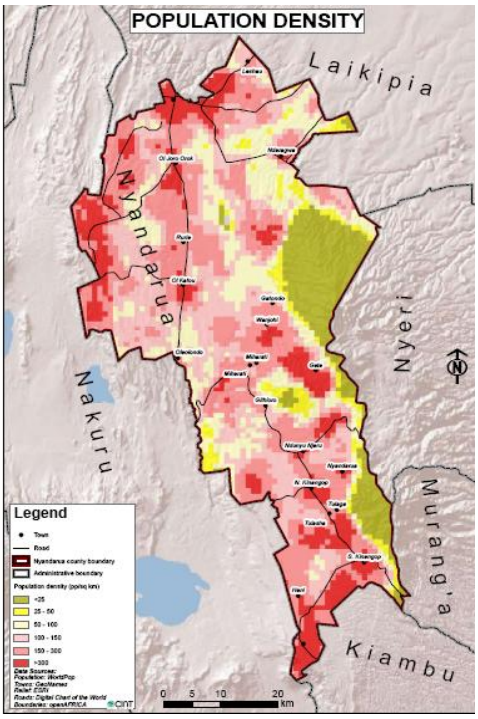
**Figure 4 Maps Showing Farming systems and population of Nyandarua County**




(a)

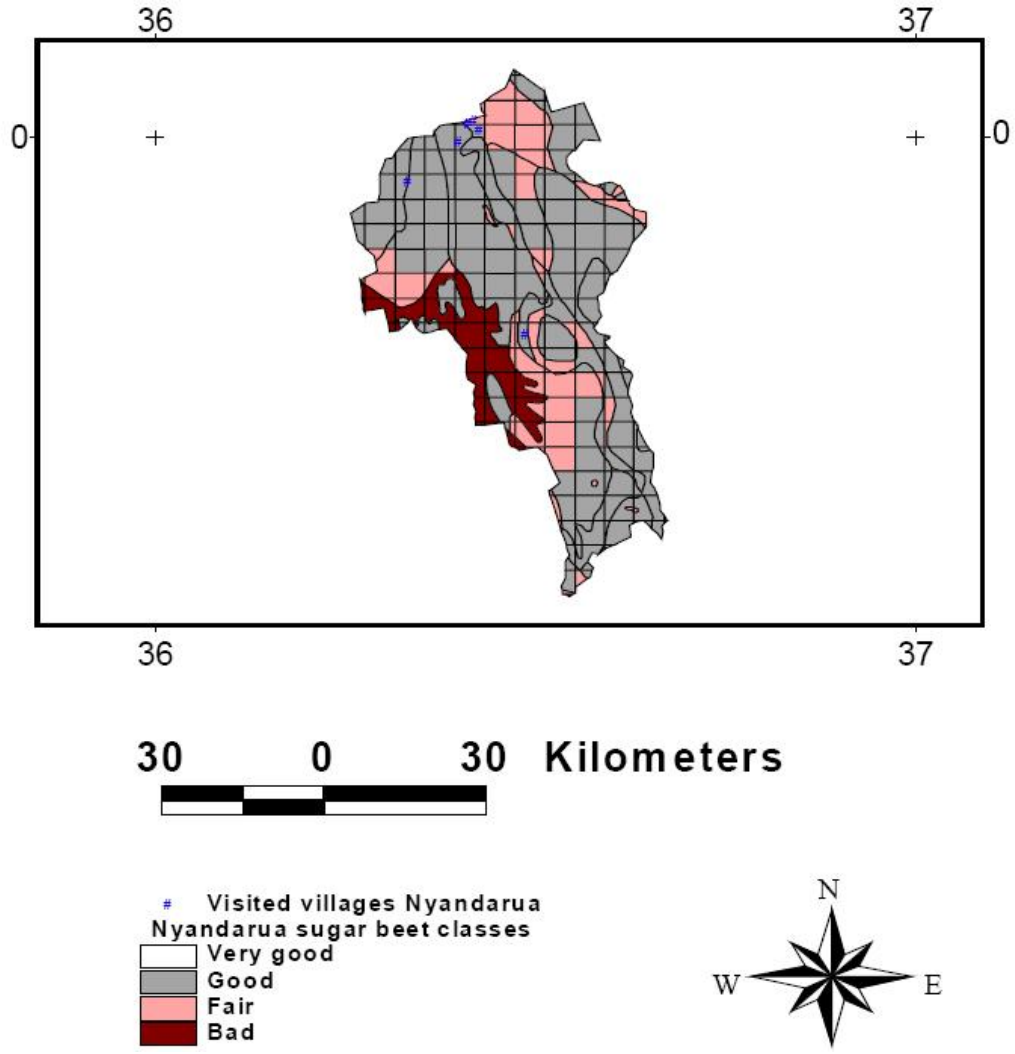



(b)




(c)

**Figure 5 Areas Found to be suitable for TSB in Nyandarua** *(Source: Mandere M.N. 2003)*




The areas that were reported to be bad for sugar beet production are those bordering the rift valley as indicated in fig.5. All other areas range from very good to fair with most part of the county categorized good. The analysis for determining suitability of sugar beet in Nyandarua was based on temperature, precipitation, soil types, soil texture. The good zones cover about ¾ of Nyadarua land area.

The areas that are reported to be bad for TSB cultivation are those that have unfavourable soil types and soil texture. These areas are also reported to have less rainfall than other areas of Nyandarua and these are bordering the escarpment of the rift valley.

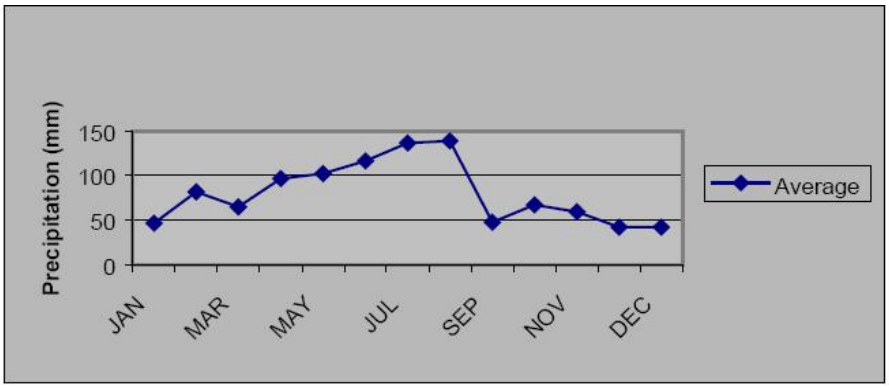
**Table 4 Rainfall and temperature data** (*2001*)

| MONTHS | STATIONS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ndaragwa F.Stat | Olbolosat | KARI (Olj.) | Karanja (Olj.) | FTC (Olj.) | Tumaini | Njabini FTC | PBK (Olk.) | Mawingo (Kip) | Wanjohi |
| January | 38.7(12) | 65.7(7) | Nil | - | - | - | 212(23) | 59(9) | 106(15) | 55.5(17) |
| Feb. | 16.2(3) | Nil | Nil | - | - | - | 15.8(7) | 5.0(1) | 15.7(2) | 23.7(6) |
| March | 81(10) | 128.7(10) | 141.7 (11) | - | 141.7 (11) | 173(10) | - | 119(12) | - | 144(14) |
| April | 7.3(3) | 209.6(15) | 131.4(8) | 196.1(15) | - | 285.5(21) | 169(16) | - | 184.6(22) | 105.6(22) |
| May | 4.0(2) | 85.7(8) | 66.8(8) | 115.6(14) | 66.8(8) | 148.5(20) | - | - | 70.7(12) | 104.3(16) |
| June | 92.7(10) | 619(7) | 54.4(4) | 265(16) | 25(6) | - | - | - | - | - |
| July | 102.4(12) | 361.5(17) | - | 306.8(21) | - | 214(17) | - | 127(15) | 107.6(15) | 100.6(21) |
| August | 116.2(13) | 119.3(16) | 223.1 (17) | 162.5(15) | 119.3 (15) | 99(10) | 25(7) | 65(10) | - | - |
| Sept. | 28.8(7) | 14(2) | 32.2(6) | 14(3) | - | - | 33(6) | - | 97.2(14) | 70.2(19) |
| Oct. | 46(2) | 62(7) | 52.6(7) | 75.4(6) | - | 131(11) | 48(7) | - | 72(15) | 98.5(20) |
| Nov. | 81(5) | 172.8(17) | 52.6(7) | 134.8(11) | - | - | - | - | - | - |
| Dec. | 24.3(11) | - | 46.1(9) | - | - | - | - | - | 80.8(21) | 115.4(22) |
| Totals | 638 (83) | 1838.3 (106) | 800.9 (77) | 1170.2 (101) | 352.2(40) | 105(89) | 508.2(66) | 395(47) | 734.6(116) | 817.6(155) |

**Table 5 Maximum and Minimum monthly mean temperatures at KALRO Olj. Met. Station (2001)**

| MONTHS(YEAR 2001) | MONTHLY MEAN TEMPARATURES | |
|---|---|---|
| | Min. ºC. | Max. ºC. |
| January | 8.9 | 21.7 |
| February | 6.6 | 25.4 |
| March | 7.6 | 24.3 |
| April | 8.8 | 22.1 |
| May | 7.7 | 22.1 |
| June | 7.2 | 20.5 |
| July | 7.1 | 19.8 |
| August | 8.0 | 20.6 |
| September | 6.4 | 21.9 |
| October | 7.4 | 22.5 |
| November | 9.6 | 20.1 |
| December | 8.0 | 21,0 |

**Figure 6 Average monthly precipitation in Nyandarua (1993-2002)**

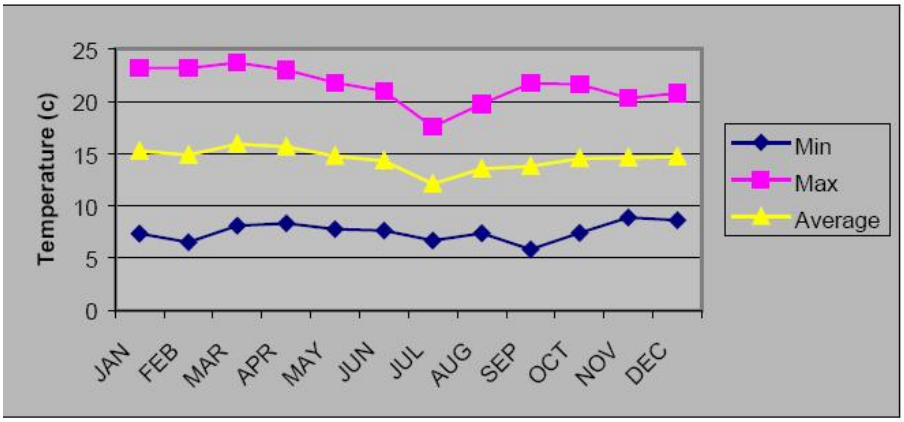



Source Kenya Meteorological Department, Nairobi (Mandere 2003)

On the 10 year average (1992-2002) precipitation appears to have a trend from the month of March and continues to to a peak of nearly 150mm during the month of August when it starts to reduce (fig. 6). The rains in October to December appear to be minimal as they are much below 100mm.

From the observed precipitation patterns, the crops planted during the month of April have a about five months with substantial rainfall that can support crop growth.

**Figure 7 Annual Temp. Variations (1993-2002)**




Data source Kenya Meteorological department, Nairobi (Mandere 2003)

Annual temperature averages indicate to start a lowering trend as from March to September (fig: 7). The maximum temperatures appear to have a slightly higher variability than the minimum temperatures. The minimum temperatures do not seem to vary much during the growing season of April to August. As the days get cooler during the April August growing season, the night temperatures remain almost the same a situation that could favour control of plant diseases associated with cold weather.

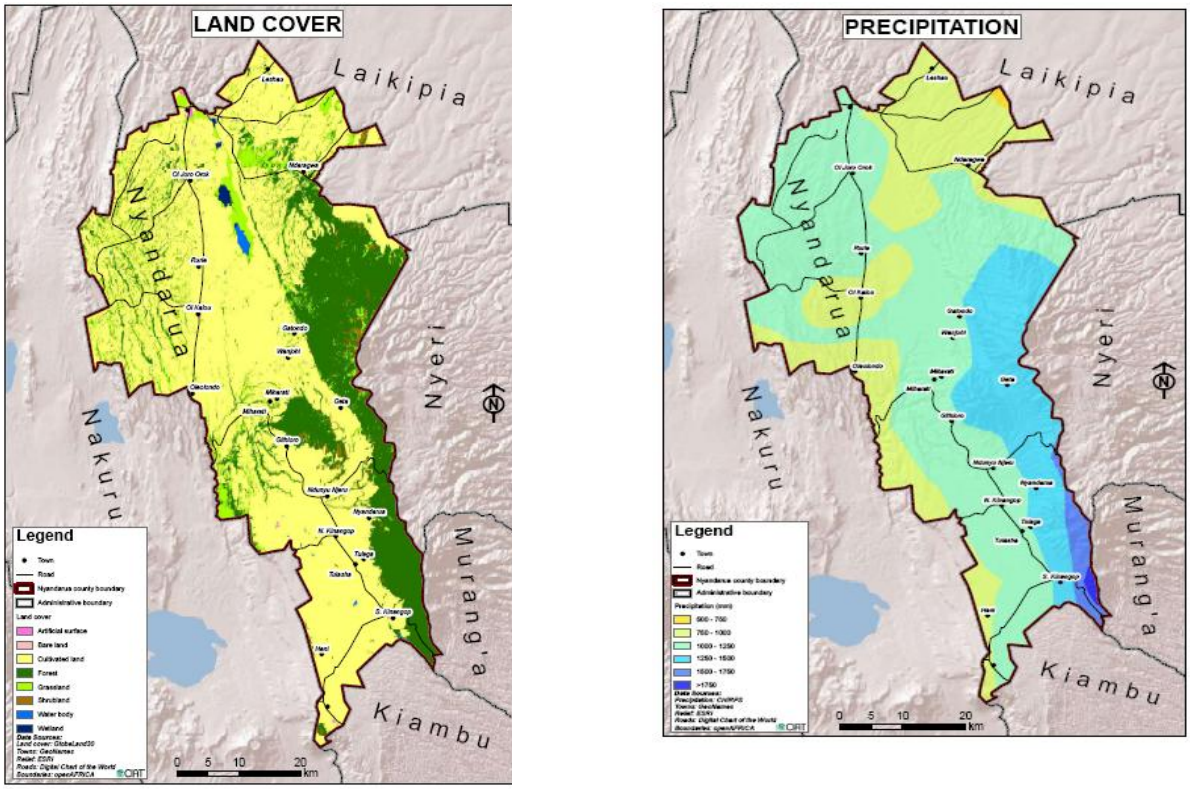



**Figure 8 Land Cover and Precipitation (a) and (b) respectively**

## Land Cover in Nyandarua

Land in Nyandarua County is characterized by the montane forest cover of the Nyandarua mountain ranges that cover a substantial proportion of the county extending across its borders with Kiambu, Muranga, Nyeri and Laikipia. Within the mountain regions the ecological conditions are those described as Tropical Alphine

## Precipitation in Nyandarua

Precipitation in Nyandarua varies from very wet on mountain forest of Nyandarua Ranges to the east bordering Muranga and Nyeri. The central part of the county receives less rainfall and therefore relatively drier while the north western part bordering Nakuru to the north is a little wetter than the middle part. However, the area within the escarpment near Naivasha receives less rainfall.

## Soils

A wide range of soils are suitable for cultivation of sugar beet. Soils must be well drained to avoid stagnation of water during the growing period. The crop can do well with pH 4 to 9 and tolerates saline soils better than acidic soils. In Nyandarua most soils are reported to be suitable for sugar beet cultivation except the rift valley escarpment bordering Naivasha where the soils ahve loose texture comprising of poorly developed and eroded leptosols with many stones and rock outcrops.

**Table 6 Dominant Soil Types in Nyandarua**

| Soil Type | %age Area | Suitability for Sugar Beet | Need of Fertilizer | Liming | Drainage Provision | Erosion Risk |
|---|---|---|---|---|---|---|
| Phaeozems | 23 | Very good | Yes | No | No | No |
| Andosols | 18 | Very good | Yes | No | No | No |
| Nitosols | 15 | Good | Yes | No | No | Yes |
| Planosols | 13 | Good | Yes | Yes | Yes | - |
| Leptosols | 12 | Bad | Yes | - | No | Yes |
| Luvisols | 10 | good | Yes | No | Yes | - |
| Alisols | 5 | Fair | Yes | Yes | No | Yes |
| others | 4 | - | - | - | - | - |

Data source: Mud Spring Geographers (2001)

Based on area coverage about 41 % is covered with Phaeozens and Andosols that are known to be very good for sugar beet while 38% of the area is covered with Nitosols, Planosols and Luvisols that are characterized as good for sugar beet cultivation. Only 12 % of the area has Leptosols that is known to be bad for sugar beet. All the soils are indicated to need fertilizer but only the Planosols and Alisols would need liming.

*Leptosol*s: Weakly developed shallow soils with little agricultural value since they are too shallow to accumulate enough water for the crops and accommodate crop root systems. This is true for a tuber crop like TSB. Leptosols are also characterized by many stones and rock outcrops that reduce further their value for agriculture.

*Andosols*: These are well drained fertile soils with good water holding capacity and high cation exchange capacity 35 -54 mmol per 100g. They have sufficient organic matter content 5-20% and are best for agriculture. This type of soil is suitable for TSB due to its good drainage and good water holding capacity Although the soil has good natural fertility and appreciable organic matter, it may still need application of fertilizers for the sake of optimizing yield.

*Nitosols*: Nitosols are deep, well drained, stable soils with high water holding capacity. They are suitable for a variety of crop types and respond well to fertilizer application in regard to increasing crop yield. The soils however, are prone to erosion. Due to the depth, structure, drainage and water holding capacity the soils are good for TSB. The main problem is soil erosion since TSB is sensitive to environmental degradation.

*Acrisols*: These are acidic soils with little natural fertility. They lack nitrogen and have certain toxic elements like aluminium. The soils are prone to soil erosion. The pH need to modulated trough liming for optimal TSB production. Liming increases the pH and also reduces the concentration of toxic elements such as aluminium.

*Phaeozems*: Fertile soils with good water holding capacity. They have organic matter content greater than 1% and are not hard when dry. The characteristics match well with the optimal requirements for TSB production. There will be a need for fertilizer application to boost TSB crop yields

*Alisols*: They are acidic with a base saturation less than 50%. Another characteristics are similar to those of acrisols.

**Table 7 Results of Soil analysis done in Kiriita during TSB trials**

| Name | J. Munene | | F. Gachingiri | | C. Wakahindo | | G. Wainaina | |
|---|---|---|---|---|---|---|---|---|
| Date Sampled | 27/3/01 | | 27/3/01 | | 27/3/01 | | 27/3/01 | |
| Field Design. | C1 | C2 | A1 | A2 | D1 | D2 | B1 | B2 |
| Lab. No./2001 | 064 | 065 | 060 | 061 | 066 | 067 | 0662 | 063 |
| Depth | TOP | SUB | TOP | SUB | TOP | SUB | TOP | SUB |
| Colour | - | - | - | - | - | - | - | - |
| PH | 5.2 | 4.6 | 5.4 | 5.0 | 4.5 | 4,6 | 4.8 | 4.6 |
| Na. m.e (%) | 0.48 | 0.32 | 0.48 | 0.64 | 0.28 | 0.20 | 0.36 | 0.32 |
| k.m.e.(,,) | 1.24 | 0.73 | 0.54 | 1.48 | 0.55 | 0.32 | 0.82 | 0.80 |
| Ca.m.e.(,,) | 5.6 | 3.6 | 4.0 | 11.2 | 5.2 | 4.4 | 4.4 | 4.8 |
| Mg.m.e.(,,) | 2.85 | 2.74 | 2.43 | 2.47 | 1.96 | 1.20 | 2.15 | 2.18 |
| Mn.m.e.(,,) | 1.43 | 0.28 | 1.37 | 1.60 | 1.64 | 0.49 | 1.10 | 0.63 |
| P.m.e.(,,) | 24.2 | 14.7 | 21.1 | 44.4 | 14,9 | 16.2 | 13.3 | 18.4 |
| N. (,,) | 0.38 | 0.25 | 0.25 | 0.66 | 0.33 | 0.33 | 0.4 | 0.28 |
| C. (,,) | 2.58 | 1.42 | 1.03 | 3.09 | 1.90 | 1.63 | 2.10 | 1.97 |
| Hp. M.e.(,,) | 0.3 | 0.5 | 0.2 | 0.2 | 0.6 | 0.6 | 0.4 | 0.5 |
| E.c | - | - | - | - | - | - | - | - |
| Fe. ppm | 37.02 | 26.82 | 20.57 | 26.39 | 24.78 | 51.52 | 21.70 | 56.99 |
| Cu. ppm. | 0.6 | 2.2 | 0.60 | 0.80 | 0.5 | 0.8 | 0.5 | 0.8 |
| Zn. Ppm | 3.98 | 8.43 | 2.73 | 2.35 | 6.34 | 6.76 | 3.28 | 3.62 |
| P. olsen. ppm. | - | - | - | - | - | - | - | - |

The comments derived from the soil analysis include:

C1 and C2 –Soil reaction indicated soil is acidic. Addition of limestone was recommended. Bases e.g. potassium, sodium, calcium, Mg. Mn, N, and Cu++, were adequate. P was low.

A1 and A2-Soil reaction shows soil acidity . Liming was recommended to raise pH.

Bases are adequate eg. Na, K+, Mg+, Mn, and Ca++. Nitrogen levels are above marginal levels, hence no need for addational nitrogen fertilizers. Carbon varies from moderate to adequate. Cu and Zn very low (need to apply fertilizers with Cu++ and Zn ++)

Fe content are high (Should be discontinued). Hp indicates rising levels of exchangeable acidity.

P is poorly supplied. Apply organic manures.

D1 and D2-

Soil reaction reflects low pH levels. This also shown by Hp data. Limestone addition recommended .Na+, Ca++, K+, Mn++, Mg++, N, Zn++ are adequately supplied. Fe++ is present in toxic quantities (avoid Fe++ fertilizers). P is poorly supplied. Application of organic manure recommended. Cu++ is low. Apply appropriate copper containing fertilizers.

B1 and B2-

Soil tests indicates pH is very acidic. There is urgent need to raise pH through limestone application. Bases e.g., Na+, K+, Ca++, Mg++, Mn++, are adequate. However P, N, Cu++, and Zn are too low. Fe++ levels are toxic (avoid Such fertilizers) Hp levels are on the rise, indicating acidity levels are increasing. Raise of pH to lower Hp levels is recommended to avoid possibility of levels that would impair growth.

## Sugar Beet diseases in Nyandarua

While there are a number of diseases that affect sugar beets, two are thought to have high to very high chances of occurring.

**Table 8 Sugar Beet diseases with high chances of occurring in Nyandarua (Mandere 2013)**

| Potential disease | Thriving conditions | Likelihood | Seriousness | Resistant/ tolerant varieties | Chemical treatment |
|---|---|---|---|---|---|
| Cercospora | Temperature (25-32 ° C), 6% humidity | high | high | yes | yes |
| Downy mildew | Temperature (4 –7 ° C), wet weather, 80-90% relative humidity | Very high | Very high | Yes | yes |

Data sources: (George, A.N. 1997; Kung,u, J.N. and E.R. Boa 1997 and Duffus, E.J. and Ruppel, E.G. 1995 and interview with Kiriita Agricultural Self Help Group)

Literature shows that there are many disease likely to affect sugar beet crops in Kenya (Mandere 2003). The potential Sugar Beet diseases in Nyandarua are Cercospora and Downey mildew. The chances for both diseases occurring and causing serious effects are high or very high. There could be sugar beet varieties resistant to the two diseases. However, chemical treatments are available for the both diseases are known to be effective

*Cercospora*: A disease that thrives at 25 to $32^0$ C in humid weather with 60% relative humidity. It affects the leaves of sugar beet plant. It develops brown necrotic leaf spots in most of the leaf surface, eventually making the affected leaves to fall off. Since leaves are important in plant photosynthesis. The result will be poor root yields in terms weight as well as low sugar content. The amount od loss in weight and the amount loss in sugar content will depend on the stage in which the sugar beet have been infected and the intensity of the infection. The disease has to be controlled if any substations yield has to be achieved. However, there are commercial sugar beet varieties resistant to cercospora disease. The disease can be controlled effectively through use of disease free seeds, crop rotation (2-3 years) and application of a wide range of fungicides.

*Downy Mildew*: A disease that thrives well in temperature range 4 to 7 $^{0}$C and in wet weather. In areas with high relative humidity (80 – 90 %) the disease can thrive at even higher temperatures The disease attacks young seedlings where it affects the leaves making them "wither, yellow and die". The disease has a potential of destroying up to 90% of the crop when young. It is worthy to note that there are commercial varieties resistant to the disease. The disease can also be effectively controlled or reduced by early sowing, crop rotation and by the use of a variety of fungicides.

## Baseline Scenarios in Narok

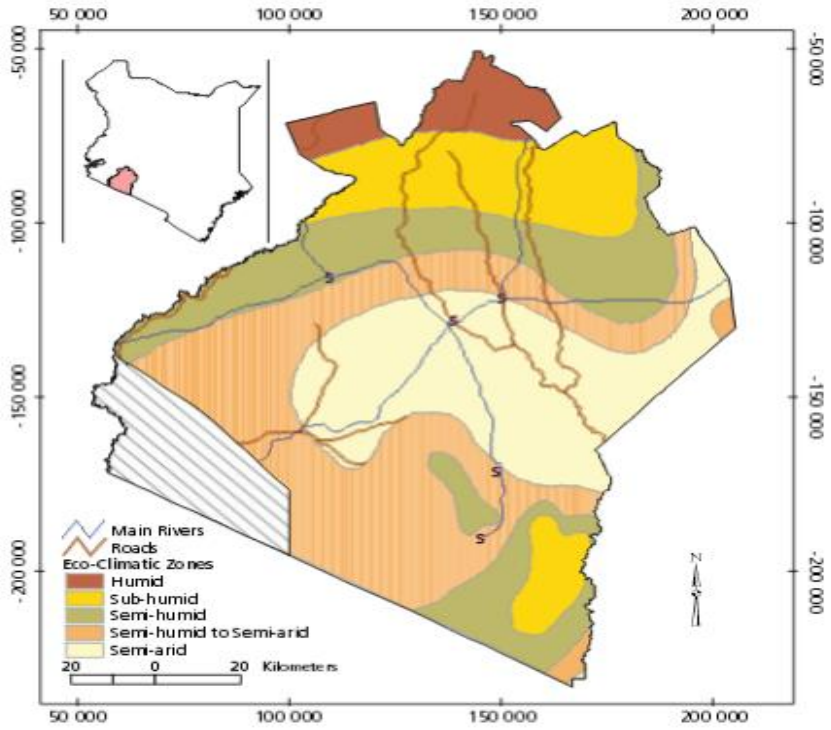
Narok County is located in central part of the Rift valley of Kenya along the western flanks of the valley bordering with Tanzania on the western side where the world famous Maasai Mara worldlife conservancy is located. On the western side of the county landscape is characterized by the western Rift Valley escarpment that is cooler and wetter than the vast dry lands of the Rift Valley.

The county has two major land uses demarcated by the Rift escarpment where pastoralism is the major land use east of the escarpment; wildlife conservation forms a substantial amount of land use, followed by cultivation. Crops grown are mainly wheat and barley, but other crops like maize and Irish potatoes are grown at both large scale and small scale farming.

Large scale farming is practiced in a number of places in Narok for the production of wheat and barley that is used for brewing by Kenya breweries.

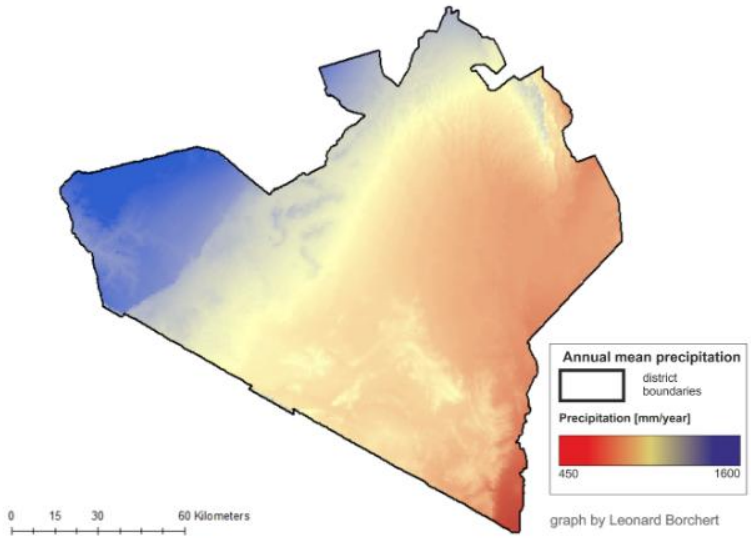
Rainfall in Narok increase with altitude from the floor of the rift in the central part of the county towards the western side as one ascend  the escarpment.

**Figure 9 Agro - Ecological Zones of Narok County (Masai Mara National Reserve is shaded in blue lines)**



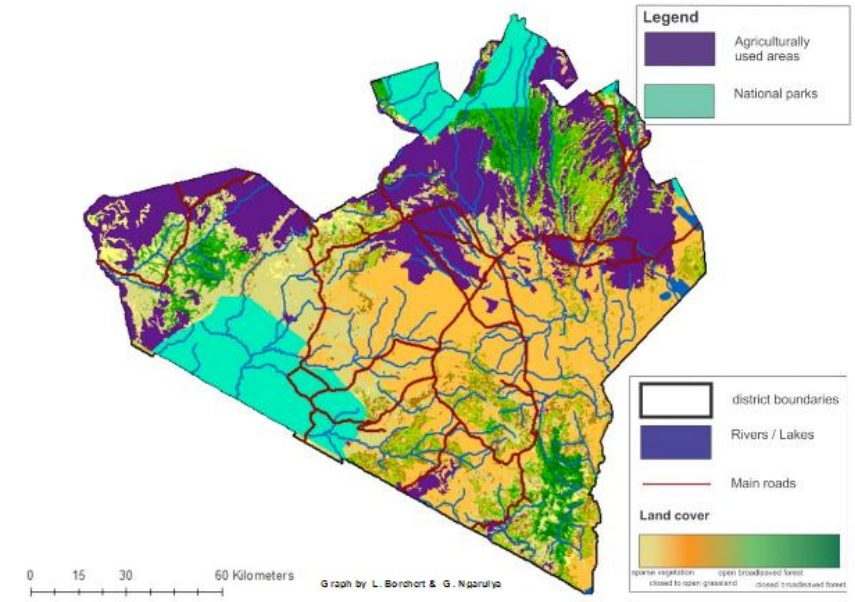

Most part of the County is semi arid to semi humid. The areas of the county most suitable for agriculture are the humid, semi-humid and sub-humid where rainfall is sufficient to support cropping (fig.9).

**Figure 10 Mean Annual Rainfall in Narok**




Source: WorldClim (Global climate data) (http://www.worldclim.org/)

**Figure 11 land use and Land Cover in Narok**




Source of data: GLAC (Global Land Cover 2000 project) (http://www.diva-gis.org/Data)

**NB: Due to change of plans by the management, production of sugar beet in Narok has been put on hold. This report will therefore not discuss more on Narok County.**

# Adapting the best practices to the piloting site in Nyandarua County

Nyadarua has two seasons; the long rains come in March – May and the short rains come in October to December. Sugar beets can be planted in any of the two seasons but cropping during the short rains may require a little irrigation as rains may be less to sustain the crop to maturity. However, with the uncertainties of rainfall timing and amounts of precipitation brought about by climate change, it is good to have a stand by irrigation gear at all the time should rains fail or delay in coming on time.
Planting and weeding can be done by hand for the pilot plot but mechanization should be put in place for most activities during the large scale operation.

Activities prior to planting of the pilot crop:

i. Identify the location of the farm to be used for TSB production. The farm should be as much as possible the same or similar to that intended for full scale production of TSB.
ii. Part of the issues to ascertain on the site is availability and the source of water to be used for irrigation if need be.
iii. Obtain soil sample (s) from the farm and take to KALRO (KARI) for testing of the pertinent soil chemical properties such as pH, nitrogen etc, in order to determine any need for fertilizer application
iv. Determine to source of labour and make logistical arrangements to have it available before the start of the season
v. Identify the tractor for ploughing and hallowing before the rains
vi. Determine the type of seeds to be planted and the source and make arrangements to have them ready at the time of planting
vii. Identify a day to day care taker who will reside on the farm on a full time basis to overlook and report the situation to Ecodym office daily. The care taker will also take custody of the farm implements and inputs that may located on site
viii. Make a site house where the caretaker will reside

## Land acquisition and Preparation for the Piloting crop

Land for the piloting crop has been identified and negotiations have been completed. The land is located in Kirima Location / Sublocation of Ol Kalou Sub County along the Njabini Ol Kalou Road. According to a care taker at the farm, the land measures about 50 acres, but the size of the land to be leased for piloting is only 20 acres. The rest of the land will be left for use by the owner.

The 20 acre leased land will be ploughed in August and hallowed in early September in readiness for planting the crops including sugar beet early October according to the onset of the rains.

## Planting of Sugar Beet for the Piloting crop

It is anticipated that the Sugar beet for the piloting crop will be planted in in early October 2017 in a portion that of the leased 20 Acres farm. The two portions will be planted with Wheat and Canola respectively. If a fourth crop is identified, the leased land will be apportioned into four lots and each planted with a type of the crop.

Planting will be done in rows across the gradient as per the specification provided in this report (see details of planting in the general information above).

## Crop Rotation

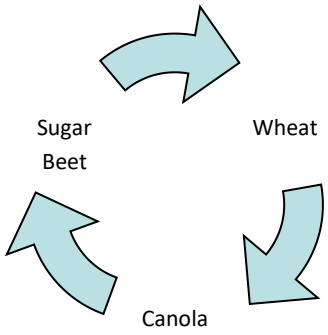
A field survey in Nynadarua identified two crops that are cultivated in the area that are suitable for rotation with sugar beet based on seasonality. These are wheat and Irish potatoes. Maize takes a full year (two seasons) in the field and therefore using it as a rotation crop will limit the number of crops planted before a return of sugar beet to the same field. Rotating with potatoes that is also a tuber crop like TSB, may interfere negatively on soil fertility as they both could be utilizing same soil nutrients and therefore act as competitors for soil chemical essential tuber crops.

Wheat is therefore the only crop currently grown in the area that is suitable for rotating with TSB. Literature recommends an oil crop as a good rotation crop. Currently there is not oil crop crop grown in the area visited by the team but inquiries on a potential oil crop suitable for the area indicate that Canola is planted in an area of Nyandarua bordering with Nyeri County and not too far away from where we intend to base the cultivation of TSB.

If it will be acceptable to introduce Canola in Nyandarua, then it can be a second ration crop after wheat. Other things that need to be considered before introducing Canola in Nyandarua are the climatic conditions, soil properties and the market potential of Canola oil.

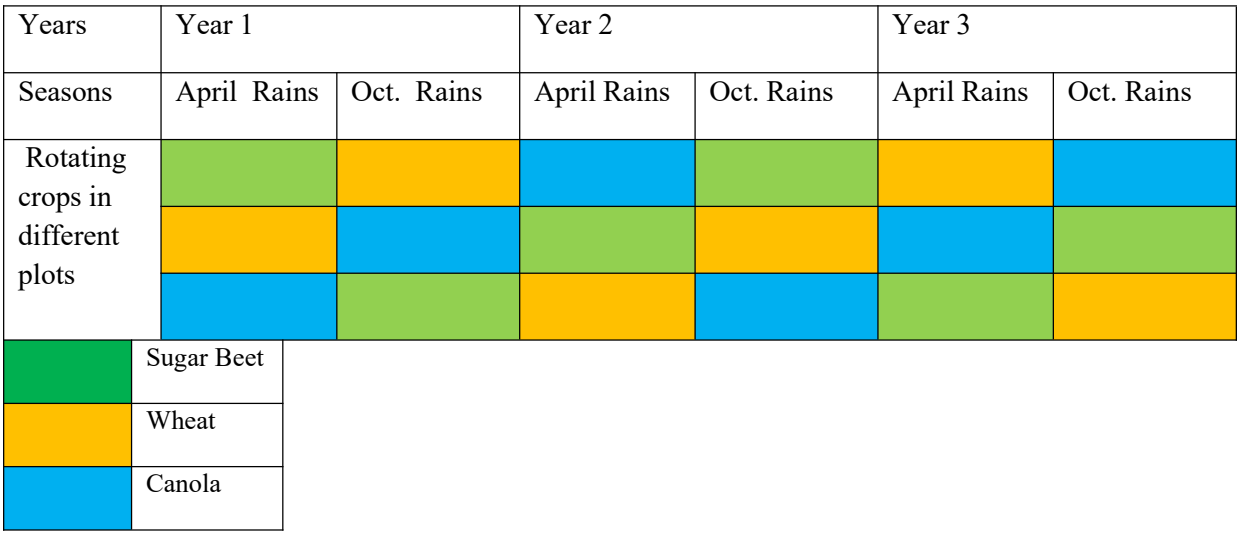
With wheat and canola alternating with sugar beet as seasonal crops, the required benefits of crop rotation to maintain soil fertility and reduce disease infestations. Literature and experiences in Europe and northern hemisphere recommend four alternating rotation crops but there is no report sayng that three crops are not adequate.

Figure 12 Seasonal Rotation Sequence for three crops in a single plot



In this sequence each crop will move to the next field after one season of 6 months. A crop will be back on the same field after 1 year.

**Figure 13 Seasonal Rotation Patterns for three crops**

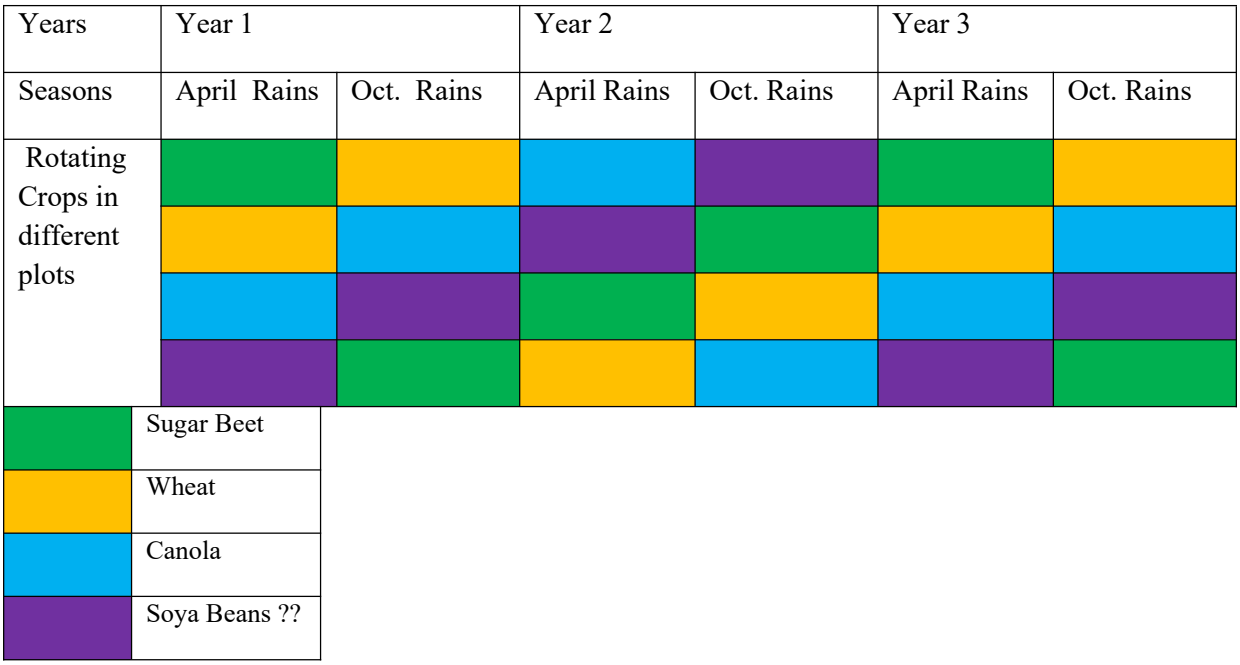



In the event that a suitable fourth crop is identified and a decision is made to work with four rotation crops, appropriate permutations plan will be designed in a similar way as the above.

A candidate 4th crop for the piloting stage is snow peas. Snow peas does well in Nyandarua and can be a good 4th rotation crop. However, during the full crop production in large scale, where each rotation crop will be cultivated in approximately 1,000 acres, there may be logistical problems in harvesting and selling snow peas from such a large area because it has to be done within a very short time.

With three crops of rotation one cycle of ration will be taking 3 seasons which is 18 months. The advantage of this is that sugar beets will be alternating the seasons as well. However, the period before the next similar crop will be only 12 months which may be too short. If a plot is planted with sugar beet in April rains during year 1, it will be planted with sugar beet in year 2 during the October rains.

**Figure 14 Seasonal Rotation Patterns for four crops**




Using four alternating crops gives a period of 18 months before the next similar crop on the same plot. This may be adequate time for the soils to stabilize in mineralization processes, and get rid of disease vectors in the soil before the next crop.

An issue to deal with is that particular plots will be producing sugar beets in specific seasons only. A plot planted with sugar beet during April rains in year 1 for example will also be plant with sugar beet during April rains in year 3. This means that specific plots will be planted with sugar beet in similar seasons over and over again.

## Fertilizer applications and weeding during the Piloting

Fertilizer will be applied after the crop has germinated. It is not envisaged to use animal manure as the land appears to be relatively fertile. The land has been fallow for some time and livestock have been grazing on it. Weeding will be done by hand using local labour. Casuals will be hired for daily labour or each will be assigned portions to remove the weed.

## Standby Irrigation Gear

The layout of the planting design will be made in such a way that passage ways will be left for water pipes to be used for pumping from the adjacent river to a central location of the farm from where watering lines will be laid. It is suggested to use overhead irrigation systems with movable sprinklers that can be shifted around the farm from point to point after a given period of time in one spot.

The irrigation gear comprising of a water tank (approx. 10,000 litters), sufficient length of piping to draw water from the river to the storage tank and sufficient length of reticulation

pipes. A good number of overhead sprinklers will also be purchased to be kept in store for use.

## Pesticide and Fungicide Applications

The need to spray with pesticides and fungicides will be as need arises. We will be ready with a stock of pesticides and fungicides or identify a sources where supply can be obtained quickly when need arises. We will be keen on monitoring to detect any infestation on the crop and apply the treatment early enough before causing any damage.

## Monitoring of crop wellbeing

We will have a care taker on the ground who will be observing the wellbeing of the crop on daily basis. The caretaker will be trained on what to observe as an indicator of good crop and what to observe as an indicator of a need for intervention. The caretaker will be making daily records of observation on certain indicators and communicate to Ecodym Office in Nairobi on a regular basis. Monitoring will cover all the crops comprising of the sugar beet and all other rotation crops in the areas identified for rotation with sugar beet.

## Harvesting of Piloting Sugar Beet

It is expected that sugar beet will beet will be harvested from the 5$^{th}$ month after planting. Before harvesting, observations will be made to establish maturity of the crop. The harvested sugar beet crop will be used to determine the quality and quantity of sugar. Quantity will be calculated on harvested tonnage of sugar beets per acre. Quality will be determined by the standard methods of measuring sugar quality in terms of sucrose content.

## Manual processing of Sugar from TSB and mapping by product usage

The sugar beets harvested in the pilot crop will be extracted manually because extraction factory will not have been set up. If necessary, samples may be taken abroad (possibly India) for formal (industrial) processing, and formal testing of ease in extraction and the sugar quality.

Production of by products of sugar processing will be assessed in amounts, quality and uses. The need for secondary processing of by products will be considered. The need for further processing of pulp for example will be determined according to market demands. Markets for all by products will also be assessed and the economics of secondary industries will be worked out.

**Table 9 Pilot Field Activities Implementation Plan for all crops**

| Activity | Approximate time in months and weeks | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months | 1 | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | | | 6 | | | |
| Weeks | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Ploughing | | | | | | | | | | | | | | | | | | | | | | | | |
| 1st Hallowing | | | | | | | | | | | | | | | | | | | | | | | | |
| 2nd Hallowing | | | | | | | | | | | | | | | | | | | | | | | | |
| Fertilizer appl. ??? | | | | | | | | | | | | | | | | | | | | | | | | |
| Planting | | | | | | | | | | | | | | | | | | | | | | | | |
| Weeding | | | | | | | | | | | | | | | | | | | | | | | | |
| Potential insecticide /fungicide | | | | | | | | | | | | | | | | | | | | | | | | |
| Monitoring | | | | | | | | | | | | | | | | | | | | | | | | |
| Harvesting | | | | | | | | | | | | | | | | | | | | | | | | |

NOTE

1. Need for a second weeding will be evaluated on site
2. Need for watering of plants will be considered during between week 6 to week 10 or as need arises.
3. All rotation crops will be planted and harvested at the appropriate time for each
4. Rotation crops will be managed based on the local knowledge and experiences

## The Piloting Farm

The proponent has leased a total of 22 acre farm for piloting the cropping of sugar beet and other associated rotation crops. One piece of land measures approximately10 acre, while the other piece measures approximately 12 acres making a total of 22 acre. The two parcels are separated by a narrow portion currently used for grazing livestock and as a passage for livestock to a wider grazing area that is also a plantation woodlot with young Eucalyptus trees.

Soil samples were collected from the leased farm and taken to KALRO for nutrient analyses. The locations were the samples were collected were marked with GPS way point so that in the future the same spots will be sampled again to to monitor changes in the soil chemical properties.

If we will choose to pilot all the four crops i.e., sugar beet plus the three rotational crops, we will apportion both parcels into two equal parts where each portion will be plated with one type of crop. The portions will be perpendicular to the river so that each will have a face towards the river for ease in watering during irrigation. However, crop rows will be across the contours to avoid soil loss through erosion. Parcel 1 is appears to have a slight gradient towards the river so, the rows will along the side that is parallel to the river.

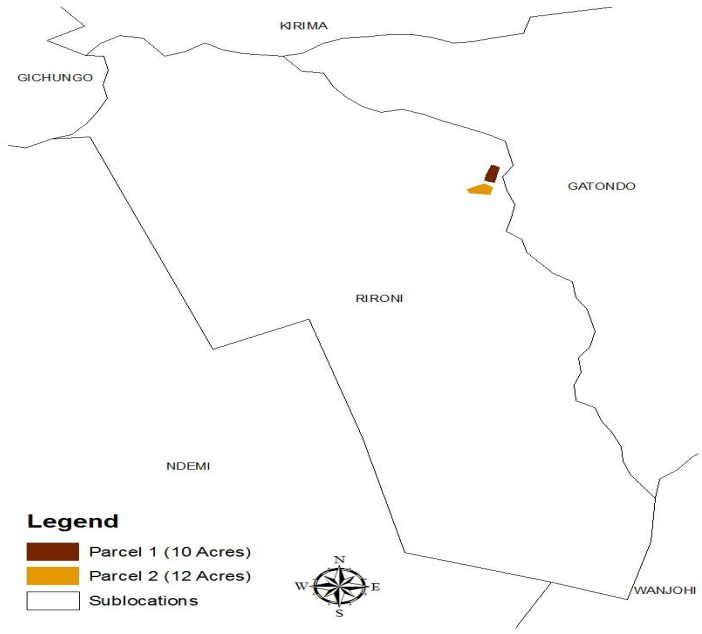
## Personnel Arrangements during the Piloting

The key person on the ground is Mr. Kariuki proprietor of Aberdare View Resort. He helped in identifying the land for piloting and he is helping in identifying bigger farms where full production will be based. He will continue to help the teams with logistical arrangements and be our link to the County and other local administers in Nyandarua.

We will need to have a person to manage the farm on a day to day basis and report to Ecodym Africa regularly on the performance and safety of the crops. He will be responsible of hiring labour whenever needed and supervise their work.

On technical grounds we will consider to have either an intern or a young agricultural / agronomy graduate who will be either stationed there or be visiting the farm regularly to check on the wellbeing of the crops. He/ She will report on any immediate technical intervention needs that may be required from time to time.

**Figure 15 Map of the Sub Location showing location of the piloting land**




The plot proposed for pilot production is located along the Wanjohi Al Karao road and borders a permanent river that can be used for irrigation. Currently the land is in two parcels as shown below but in future the two parcels can be joined leaving a small path as a passage for livestock.

**Figure 16 Map showing the sizes of the two land parcels for piloting**


Parcel 1 is 10 acres, and parcel 2 measures approximately 12 acres. In total the two parcels have approximately 22 acres.

# Conclusions and Recommendations

The use of the pilot study can significantly reduce the risks associated with adopting novel or new approaches to projects. It also enables organisations to get firmer ideas on costs and benefits of a project before committing available resources to large operations.

This report has been put together by synthesising available information from literature on TSB cultivation in Kenya, general literature on sugar beet cultivation together with farmer's experiences in Nyandarua. The report is intended to provide information for the piloting of sugar beet cultivation on a small scale and subsequently feed into the proposed plans for large scale production of TSB. It is expected that with experiences on a 20 acre farm, it will be possible to cultivate a thousand acres or more on a seasonal rotation basis with either three crops or four per season.

We recommend that planting materials like TSB seeds and those for the rotation crops be availed in time so that activities can be on time.

On site care taker to manage labour and service inputs, look after the materials like farm implements, seeds, fertilizers, pesticides and others that will need temporally storage on the farm. The care taker will be inspecting thoroughly on a day to day basis how the crop is doing and report any changes observed to Ecodym Africa in Nairobi for appropriate and immediate intervention. The caretaker therefore will be trained on the indicators to monitor to mark the wellbeing of the crops and capture at the earliest time possible any incidence plant pests, plant diseases or need for soil nutrient inputs or watering.

On crop rotation the management has to decide on whether to practice rotation during the piloting stage of just pilot the production of TSB. There may be no need to pilot cultivation of wheat because it is grown in the area and marketing of wheat harvests is already known. However Canola should be piloted because it will be introduced in the area for the first time.

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# Appendices

Appendix: 1. Historical weather data for Ndaragua

## CLIMATE TABLE // HISTORICAL WEATHER DATA

| | January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avg. Temperature (°C) | 14.5 | 15 | 15.4 | 15.6 | 15 | 14.2 | 13.7 | 13.6 | 14 | 14.5 | 14.4 | 14.2 |
| Min. Temperature (°C) | 5.8 | 6 | 7.1 | 8.6 | 8.2 | 7.1 | 7.3 | 7.2 | 6.3 | 6.9 | 7.8 | 7 |
| Max. Temperature (°C) | 23.2 | 24 | 23.8 | 22.6 | 21.9 | 21.3 | 20.1 | 20 | 21.7 | 22.1 | 21 | 21.5 |
| Avg. Temperature (°F) | 58.1 | 59.0 | 59.7 | 60.1 | 59.0 | 57.6 | 56.7 | 56.5 | 57.2 | 58.1 | 57.9 | 57.6 |
| Min. Temperature (°F) | 42.4 | 42.8 | 44.8 | 47.5 | 46.8 | 44.8 | 45.1 | 45.0 | 43.3 | 44.4 | 46.0 | 44.6 |
| Max. Temperature (°F) | 73.8 | 75.2 | 74.8 | 72.7 | 71.4 | 70.3 | 68.2 | 68.0 | 71.1 | 71.8 | 69.8 | 70.7 |
| Precipitation / Rainfall (mm) | 33 | 35 | 59 | 115 | 81 | 66 | 101 | 111 | 53 | 57 | 95 | 69 |