PRELIMINARY DESIGN OF A DRIP IRRIGATION SYSTEM FOR MAIZE CASE STUDY LWAMPANGA SUBCOUNTY, NAKASONGOLA DISTRICT.

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Abstract: Uganda has been experiencing El Niño and La Niña the dual phenomena. The effects have since become increasingly hostile characterized by drought, shortened and erratic rainfall seasons, leading to reduced crop production, poor rangeland conditions in pastoral areas and food insecurity.

Drip irrigation is a powerful intervention to combat the situation ensuring that all year round cultivation can be afforded with good yields. This is because it ensures efficient utilization of water and minimizes wastage as water goes directly where it is needed.

Investigations of the soil, climatic data and topography were carried out to establish the suitability of the chosen site for drip irrigation and the crop water requirement for maize.

Results showed that the conditions of the soil, climate and proximity to Lake Kyoga made it suitable for irrigation of maize using drip technology. The preliminary design of small scale irrigation system using water abstracted from Lake Kyoga was successfully done and included; a topographic survey, soil and water quality tests, pump and the pipework's for the system using EPanet software.

Since the water and soil parameters tested satisfy FAO Irrigation standards of Maize, it means that the plot (0.96ha = 2.37acres) and can be grown two times a year with a growing season of 125days.The net irrigation water supply of at least 142.9 mm to cater top up and meet the required 800mm of actual crop water requirement for maize per crop per growing season.

Index Terms **– Agricultural, Drip Irrigation for maize, Topography survey, soil test, water balance, water quality test, CROPWAT software, Epanet software.**

1.INTRODUCTION

The emerging threat to sustainability of agriculture globally requires a paradigm shift in the way irrigation is practiced; the rapid increase of the world population and the corresponding demand for extra water by water users forces the agricultural sector to use its irrigation water more efficiently (Andarzian et al., 2011).This entails adoption of irrigation water management strategy that can facilitate the achievement of the goal of producing more crops per drop of water, which is the use of drip irrigation system and adoption of deficit irrigation scheduling among others (Molden et al., 2003; Kendall, 2011; Igbadun et al., 2012).

Globally agriculture makes use of available water accounting for about 70% of all use. In countries where agriculture is the main activity as in India and Africa, 90% of water is used for agriculture entailing use of irrigation. It has been found that because of temporal and spatial variations potential in usable water supply is small (Megh, 2014).

In sub-Saharan Africa there are many constraints on the spread of low cost drip irrigation, such as lack of basic infrastructure and the absence of developed markets. With its strong infrastructure and new water policy reforms focused on the poor, South Africa is a logical place to demonstrate the potential of low-cost drip irrigation in the region (Postel et al., 2001). The recent implementation of drip systems in the region has meant a deficiency in knowledge of farmers' preferences concerning such irrigation technologies.

In Uganda, the population is estimated at 34.9 million people, with an average annual growth rate of 3% (UBOS 2015). Correspondingly, pressures on Earth's finite natural resources, of which arable land is one, are rising in tandem with the growing human population. The agricultural sector in Uganda contributes about 24.6% of the gross domestic product (GDP), provides livelihood for over 72% of the economically active population, and provides most of the raw materials to the mainly agro-based industrial sector (UBOS 2015). Agriculture in Uganda, which is predominantly rain-fed, is increasingly adversely affected by the climate change and variability manifested in erratic rain patterns, prolonged dry spells, and floods. Under these conditions, irrigation is critical in aiding farmers against climate change and plays an integral role in transitions from subsistence to commercial farming by ensuring year-round production and farm employment (Machethe et al. 2004; Ngigi 2009; Van Averbeke et al. 2011; Kadigi et al. 2012; Haile and Asfaw 2015; Megersa and Abdulahi 2015).

The NAKASONGOLA region which lies in the cattle corridor has been hit by food shortages after much of the area's harvests failed due to drought in the middle of 2015. The district has had high deforestation rates, with livestock keeping as the main livelihood activity.

Drip irrigation system is one of the fastest expanding technologies in modern irrigated agriculture with great potential for achieving high effectiveness of water-use. It allows judicious use of water and fertilizer during irrigation of a wide range of crops (Segal et al., 2000; Mofoke et al., 2006; Oyebode et al., 2011).Deficit irrigation scheduling has been recognized as a viable practice that could lead to increased crop yield, reduced negative environmental impact and improved sustainability of irrigated agriculture (Igbadun, 2008; FAO, 2012). Regulated deficit irrigation scheduling practice is the technique of reducing the amount of water applied per irrigation at some stages of the crop growth with the aim of saving water and in some cases energy (Prichad et al., 2004; Zhang et al., 2004; Hamid et al., 2009; Himanshu et al., 2012).

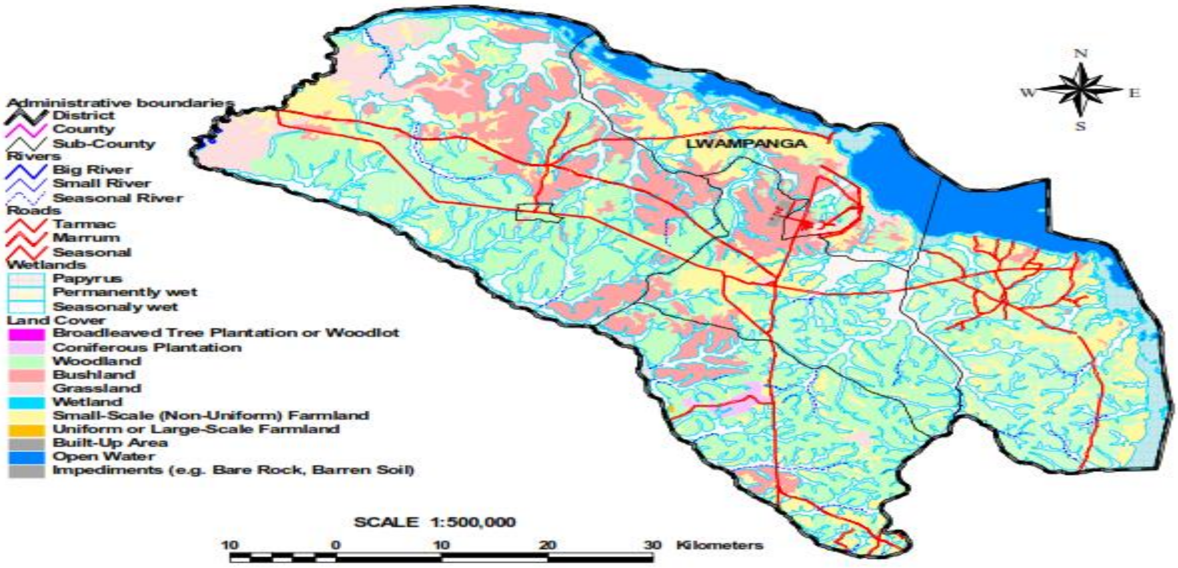
I. OBJECTIVES

1) To carry out a desk study of the existing features on site and surroundings and determine pipeline routes and proper positioning of the scheme.
2) To survey the plot and come up with a topographic survey map and carry out soil & water quality tests.
3) To determine the irrigation scheme requirements.

II. Study Area

Nakasongola District is bordered by Apac District to the north-west, Amolatar District to the north-east, Kayunga District to the east, Luweero District to the south, Nakaseke District to the south-west, and Masindi District to the north-west. Nakasongola, the main municipal, administrative, and commercial center of the district, is approximately 140 kilometres (87 mi), by road, north of Kampala, the capital and largest city of Uganda.

The map below shows the features in the district and the location of Lwampanga sub-county in which the proposed irrigation is to be placed.



Map showing features of the district. (Source: undp... et al, 2008).

2. MATERIALS AND METHODS

A topographic survey containing the proposed location of the tank and pipeline was drawn**.** An Etrex 10gps was used to execute the survey. The GPS was set to satellite mode, different points were picked while recording their relative coordinates and their relative heights. Data obtained was processed in excel spread sheets, and ArcGIS 2015 used to produce a topographic layout as attached in the appendix 1. The area of the plot was to be irrigated was 0.96hacters (9600m2; 237.27dec; 2.3727acres) and when designing the site, all proposed structures should be located within the legal boundaries to avoid disputes with the neighbours and authorities in future.

Soil Tests

After the observations were carried out, samples were taken to National Agricultural Research Laboratory (NARL), Kawanda. And the results was presented by a tabular form.

Table 2- 1 Infiltration test results (source NARL, Kawanda)

Time reading on the clock	Time Difference (min)	Cumulative time (min)	Water level reading (mm)		Infiltration (mm)	Cumulative Infiltration (mm)	Infiltration Rate (mm/min)	Infiltration Rate (mm/hr)
			Before filling	After filling				
9;00	0	0	0	100	0	0	0	0
9;02	2	2	94		6	6	3	180
9;05	3	5	89		5	11	1.67	100.2
9;10	5	10	85		4	15	0.8	48
9;15	5	15	82		3	18	0.6	36
9;20	5	20	79		3	21	0.6	36
9;25	5	25	77	100	2	23	0.4	24
9;30	5	30	98		2	25	0.4	24
9;35	5	35	96		2	27	0.4	24
9;40	5	40	94		2	29	0.4	24
9;45	5	45	92		2	31	0.4	24
9;50	5	50	90		2	33	0.4	24
9;55	5	55	88		2	35	0.4	24
10;00	5	60	86		2	37	0.4	24

Table 2- 2: Table 2- 3: Typical infiltration rates of Different soils (Source: FAO, 2002)

Soil type	Infiltration rate mm/hr.
Sand	>30
sandy Loam	30 - 20
Silt Loam	20 to 10
Clay Loam	10 to 5
Clay	< 5

Table 2- 4 Sieve analysis results (source, NARL, Kawanda)

BS sieve (mm)	Percentage retained (%)	Percentage passing (%)
20	0.0	100
10	0.0	100
6.3	0.0	100
5	0.0	100
2	1.0	99
1.18	2.0	98
0.6	4.0	96
0.425	6.0	94
0.3	10.0	90
0.212	16.0	84
0.15	25.0	75
0.075	30.0	70

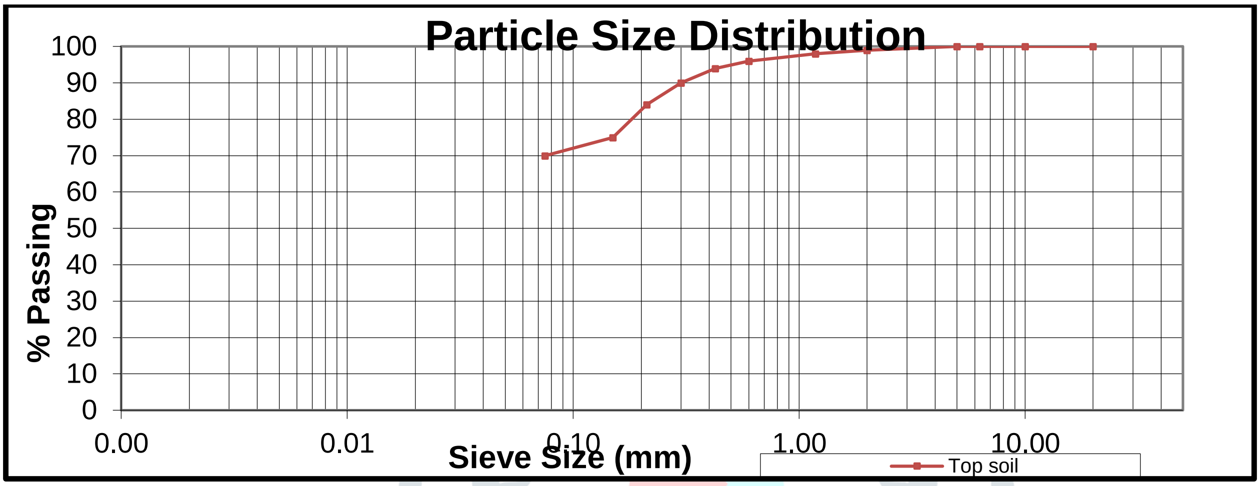


Figure 2- 1 Sieve analysis graph (Source, Excel spread sheets)

Atterbarg limits

Table 2- 5 Atterbarg limits results (Source, NARL, Kawanda)

Atterbarg limits			
Soil profile	Liquid limit (LL %)	Plastic Limit (PL %)	plastic Index
Top soil	46.6	19	27.6
Sub soil	51.8	25.1	26.7
Bottom soil	63	31	32

Liquid limit is 46.6% at 20mm penetration and the plasticity index (difference between liquid limit and plastic limit) is 27.6%. Other samples gave 26.7% and 32%. **Average liquid limit is 53.8%, plastic limit is 25.03% and plasticity index is 28.77**. **Hence the soil is sand, silt clay.**

Soil profile and Soil Hydro-conductivity test

The following results were obtained from the field and confirmed from the field

Table 2- 6 Soil profile field observations

Soil profile	Texture	Depth (m)
Top soil	Sandy loam	0.2
Sub soil	Sandy loam	0.15
Bottom soil	Sandy	1.15

Table 2- 7 Soil conductivity results (source, NARL, Kawanda)

Soil profile	Depth (m)	Conductivity (ds/m)
Top soil	0.5	4.6
Sub soil	1.0	2.7
Bottom soil	1.5	3.6

The field conductivity results through the entire profile were between the ranges of 2.5- 12.5 (ds/m) hence the soil is suitable for Maize growing. The soil was also found not to have a water table 1.5m which also makes suitable for the crop.

Soil pH

The following results were obtained from the lab

Table 2- 8 Soil pH results (Source NARL, Kawanda).

Soil profile	Depth	PH
Top soil	0.5	6.5
Sub soil	1.0	6.3
Bottom soil	1.5	6.6

Since the obtained field soil PH is within the required PH for effective maize growth that is 5.0– 7.0 (FAO, 2012) but the optimal pH is 6.0-7.0, the soil is suitable for the crop.

Other chemical tests carried out

Table 2- 9 Soil chemical test results

	OM	P	Ca	Mg	K	Na
Units	%	ppm	ppm	ppm	(mg/100g)	(mg/100g)
1	6.74	34.09	855.70	83.30	67.86	0.32
2	6.63	35.10	857.10	79.10	69.98	0.34
3	6.86	37.20	856.02	82.06	67.61	0.31
Average	6.74	35.46	856.27	81.49	68.48	0.32

Table 2- 10 Classification of soil nutrients (Source; USDA,1997)(Source, NARL, Kawanda)

	OM	P	Ca	Mg	K
Units	%	ppm			(mg/100g)
Very low	0.7-1.0	0-12	<330	<17	0-20
Low	1.0-1.7	12.5-22.5	330-655	17-46	20.5-40.5
Medium	1.7-3.0	23-35.5	655-1640	46-87	41-72.5
High	3.0-5.15	36-68.5	1640-3280	87-145	73-138.5
Very high	>5.15	>69	>3280	>145	>139

Water quality tests

Irrigation water quality tests in accordance with BS EN 14268:2005, FAO, 1985 & WHO, 1994 and the following results were obtained from the National Water and Sewage Cooperation (NWSC) Ggaba.

Table 2- 11 Water Quality test results (source NWSC Lab, Ggaba)

Parameters	Units	Results obtained	Discharge standards
PH	-	6.8	6.0-8.0
Conductivity (EC)	uS/cm	107	less 1000
Total Dissolved Salts (TDS)	mg/L	31	less 500
Bio carbonates (CaCO3)	mg/L	30	less 500
Total Suspended Solids (TSS)	mg/L	31	less 500
Ammonia Nitrogen (NO3)	mg/L	1.3	less 50
Phosphorous	mg/L	1.7	less 10
BOD	mg/L	3.5	less 50

This water showed good physical chemical qualities for irrigation and animal use since results of all the tested parameters were less than the permissible standards.

3. Discussion of results

Soil organic matter content (% OM)

Soil organic matter of 6% or more is the ideal quantity for a good soil (United States Department of Agriculture, 1997). One with soil organic matter of less than 3% is considered low and not suitable unless fertilizers or manure is applied. In the samples, the organic matter 6.74% lies in the range greater than 5.15%. This shows the soil has a very high organic matter, thus it doesn't require the addition of organic matter.

Phosphorus content (P)

Extractable or available P content is medium since 35.46 ppm from table 2-9 which lies between (23 – 35.5 ppm) in table 2-10. According to the. Extractable Phosphorus (P) is considered suitable when it has P of 20 ppm or more (United States Department of Agriculture, 1997). The soil samples tested indicated that, 35.46 ppm > 20ppm therefore the soil doesn't require the addition of Phosphorus (P) fertilizers.

Calcium content (Ca)

Calcium content is 856ppm from table 2-9 which lies between 655-1640 ppm in table 2-10, therefore it is medium in the soil, and hence Calcium containing fertilizers are not required.

Magnesium (Mg)

Magnesium content is 81.48 ppm from table 2-9 which lies between 46-87ppm in table 2-10, therefore it is medium in the soil, and hence Magnesium containing fertilizers are not required.

Potassium (K)

Exchangeable potassium (K) of 68.48 mg/100g table 2-9, in the soil samples is medium since it lies in the ranges of 41-72.5 mg/100g soil according to table 2-10. A good soil is supposed to have at least 50mg of K/100g soil (United States Department of Agriculture, 1997). Therefore, don't require the application of potassium fertilizers.

Sodium (Na)

The hazardous threshold of sodium is 16.0 mg/100g of spoil (United States Department of Agriculture, 1997). In the soil samples tested, the amount of sodium 0.32 mg/100g of soil table 2-9. Therefore, there is little concern on its effect on Maize.

CROPWAT Software

Table 3- 1 Long term 8yrs temperature, humidity, wind speed and sunshine hrs (Source, CROPWAT Software)

Table 3- 1 Climate data (source CROPWAT 8.0)

Month	Maximum temperature	Minimum temperature	Humidity	Wind speed	Sun shine
	°C	°C	%	Km/day	Hours
Jan	30.7	16.1	66	208	4.0
Feb	30.5	16.5	54	251	4.1
Mar	29.9	17.1	58	224	3.6
Apr	28.4	17.2	79	209	3.4
May	27.6	17.1	79	209	3.8
Jun	27.3	16.4	71	216	3.9
Jul	26.7	15.8	66	216	3.9
Aug	27.0	16.0	66	209	4.0
Sep	27.9	16.1	70	189	3.8
Oct	28.5	16.5	74	189	4.0
Nov	28.9	16.5	76	196	4.0
Dec	29.1	16.1	63	209	4.0
Average	**28.5**	**16.4**	**69**	**210**	**3.9**

From the table 3-1 the relative humidity of the area was 69% and Maize grow well in a humidity of 60% and above (Agrotech, 2016) hence the prevailing humidity is suitable for the plant.

From the table 3-2 the Reference crop evapotranspiration ETo was 3.95 mm/day and the Net Radiation of the earth surface Rn as 14.8MJ/m^2 per day.

Country suganda Station Nakasongola

Altitude 1045 m. Latitude 1.49 °N Longitude 32.50 °E

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	16.1	30.7	66	208	4.0	14.9	4.20
February	16.5	30.5	54	251	4.1	15.6	5.08
March	17.1	29.9	58	224	3.6	15.1	4.65
April	17.2	28.4	79	209	3.4	14.5	3.52
May	17.1	27.6	79	209	3.8	14.3	3.39
June	16.4	27.3	71	216	3.9	14.0	3.62
July	15.8	26.7	66	216	3.9	14.2	3.77
August	16.0	27.0	66	209	4.0	15.0	3.89
September	16.1	27.9	70	189	3.8	15.2	3.80
October	16.5	28.5	74	189	4.0	15.4	3.75
November	16.5	28.9	76	196	4.0	14.9	3.65
December	16.1	29.1	63	209	4.0	14.6	4.12
Average	**16.4**	**28.5**	**69**	**210**	**3.9**	**14.8**	**3.95**

Dependable Rainfall

Monthly long term mean rainfall was calculated in excel spread sheets and the data imported to CROPWAT to calculate the effective rainfall.

Table 3- 12 Effective rainfall (Source CROPWAT software)

Station Nakasongola Eff. rain method USDA S.C. Method

	Rain	Eff rain
	mm	mm
January	97.6	82.4
February	12.0	11.8
March	50.0	46.0
April	246.3	149.2
May	120.2	97.1
June	56.5	51.4
July	48.8	45.0
August	55.2	50.3
September	119.3	96.5
October	129.5	102.7
November	125.8	100.5
December	13.5	13.2
Total	1074.7	846.0

From the table the total effective rainfall was 846 mm.

Crop coefficient (Kc).

The following Kc values in initial, development and harvesting stages were obtained as 0.3, 1.2 and 0.35 respectively.

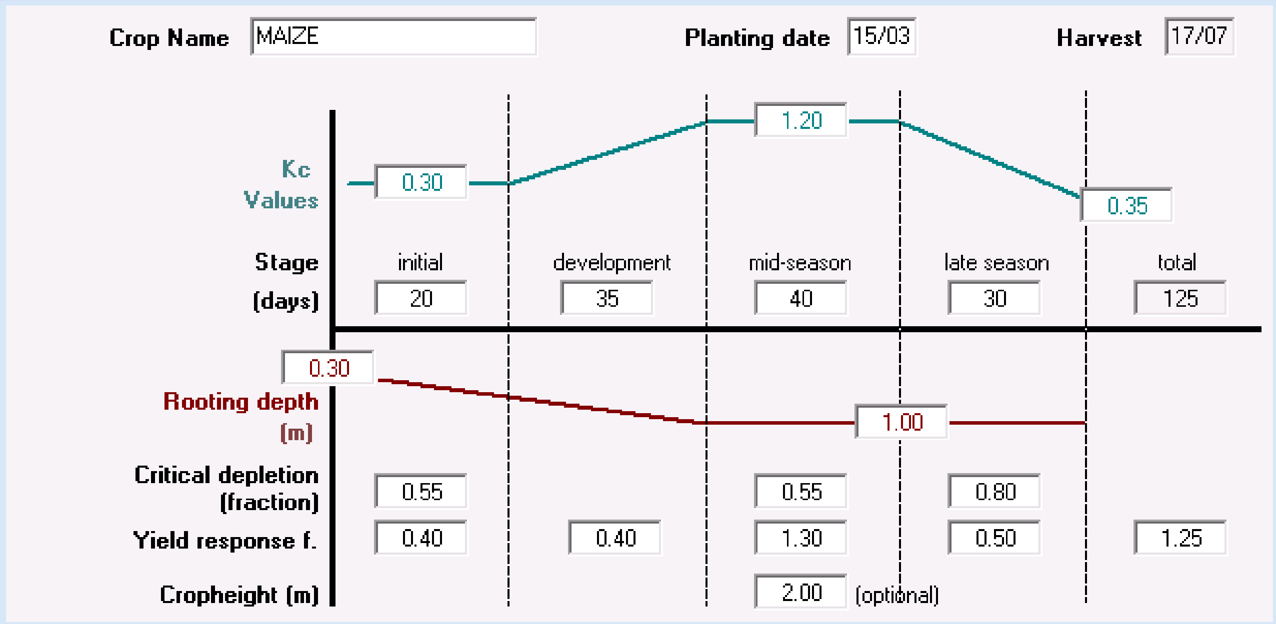
Critical depletion fraction (p)

The following values of 0.55, 0.55 and 0.80 were obtained at initial, mid and development stages from CROPWAT 8.0 software.

Crop height

This parameter was introduced in CROPWAT 8.0 in order to allow the adjustment of crop coefficient values under non-standard conditions, particularly values of relative humidity that differ considerably from 45%, where wind speed is larger or smaller than 2.0 m/s. This parameter is optional and in case it is not provided no adjustment will be done. In this project, for Maize it was provided as 2 m.

Table 3- 13 Crop data results (source CROPWAT 8.0)



Soil Module

Table 3- 14 Soil data results (Source CROPWAT 8.0)

Soil name: Sanday loam

General soil data

Total available soil moisture (FC - WP)	140.0	mm/meter
Maximum rain infiltration rate	30	mm/day
Maximum rooting depth	100	centimeters
Initial soil moisture depletion (as % TAM)	0	%
Initial available soil moisture	140.0	mm/meter

Maximum rooting depth

For this project mechanized practices were not considered, the maximum rooting depth for the crop was obtained as 100cm from table 3-6.

Crop water requirement (CWR) module

The crop_water_requirement_module includes calculations, of the irrigation water requirement of the crop on a decade basis and over the total growing season, Crop evapotranspiration under standard conditions (ETc) and the Effective rainfall.

Table 3- 15 Crop Water Requirement (Source CROPWAT 8.0)

Crop Water Requirements

ETo station: Nakasongola | Crop: MAIZE
Rain station: Nakasongola | Planting date: 15/03

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Mar	2	Init	0.30	1.40	8.4	7.2	2.3
Mar	3	Init	0.30	1.28	14.1	24.6	0.0
Apr	1	Deve	0.37	1.42	14.2	43.2	0.0
Apr	2	Deve	0.62	2.11	21.1	57.1	0.0
Apr	3	Deve	0.87	2.97	29.7	48.9	0.0
May	1	Mid	1.12	3.84	38.4	38.0	0.4
May	2	Mid	1.19	4.04	40.4	32.1	8.3
May	3	Mid	1.19	4.13	45.4	27.1	18.3
Jun	1	Mid	1.19	4.22	42.2	21.0	21.2
Jun	2	Late	1.17	4.25	42.5	15.3	27.2
Jun	3	Late	0.95	3.50	35.0	15.2	19.8
Jul	1	Late	0.67	2.50	25.0	15.4	9.7
Jul	2	Late	0.43	1.64	11.5	10.1	0.0
					367.9	**355.2**	**107.2**

From the calculations by the software an Irrigation Water Requirement (Irr. Req) of 173.4mm/dec was obtained. Crop Evapotranspiration (ETc) and Effective Rainfall (Eff rain) results were calculated as 495.7 mm/dec and 334.1 mm/dec respectively.

From the crop irrigation water requirement of 107.2 mm/dec

Therefore the amount of water required to irrigate Maize on a 0.96ha land can be taken as 1029.12m^3 of water in a season of 125 days.

Schedule module

Table 3- 16 Irrigation schedule results (Source CROPWAT 8.0)

ETo station: Nakasongola | Crop: MAIZE | Planting date: 15/03 | Yield red.
Rain station: Nakasongola | Soil: Sanday loam | Harvest date: 17/07 | 0.0 %

Table format: (•) Irrigation schedule ( ) Daily soil moisture balance

Timing: Irrigate at critical depletion
Application: Refill soil to field capacity
Field eff. 70 %

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
22 Jun	100	End	0.0	1.00	100	60	84.4	0.0	0.0	120.5	0.14
17 Jul	End	End	0.0	1.00	0	16					

Pipe system design

The available area of land to be irrigated is 9600m^2 and according to the information acquired from NARO Kawanda, for maize the irrigable area should be greater than 2025m^2. These blocks should be in a range of 900m^2 to 2025m^2. They are introduced to allow an even distribution of water around the garden. Therefor blocks 900m^2 had to be introduced on this garden.

No of blocks required = $\frac{9600}{1200}$ = 8 blocks

Table 3- 17 Areas of blocks to be irrigated

Block name	Area (m^2)
A	1200
B	1200
C	1200
D	1200
E	1200
F	1200
G	1200
H	1200

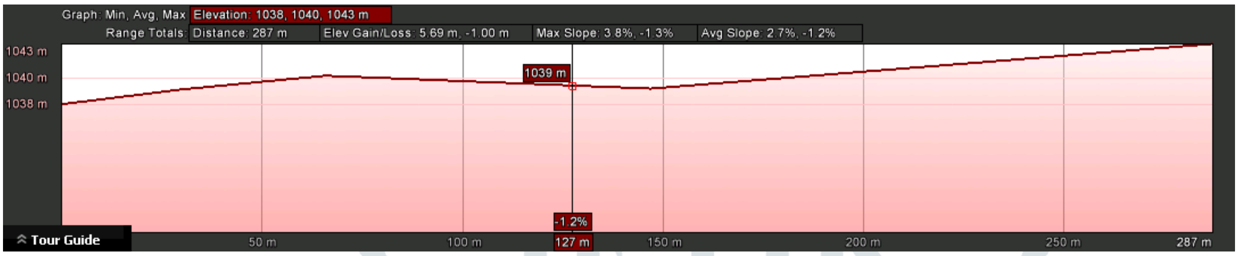


Figure 3-2: shows a cross section of the topo map for the proposed pipeline path.

Main line

The main line is designed to carry the maximum system capacity required for the plants in the farm plot; Q = 0.45 LPs. For sizing purposes we take it as 1 LPs

From tables, a discharge of 1 LPs through a pipe of 50mm diameter the friction loss would be 0.68m per 100 length.

Friction head loss = 0.68* (0.88) conversion factor = 0.5984

Because the proposed system uses multiple openings, the friction loss is taken as 1/3 of the total friction loss; that is, 0.5984/3= 0.1995m. Thus the loss in the mains is within the 1.0 m/100m and a pipe of 50 mm diameter will be ideal for the design layout.

Sub-main line

The sub-main line is designed to carry the maximum discharge required for total number of plants in the farm plot.

Maximum discharge required = No. of plants * peak discharge per plant

= 7200 * 1.72 = 1238.4 l/p/h

= 0.34 LPs

Friction Head loss in pipes (m)

Total length	=	100.0
Equivalent length	=	32
Straight connectors	=	16
Equivalent length of tee, bends etc	=	13
Total length	=	129 or 130 m

From standard tables, It would be seen that for a discharge of 0.34 LPs through a pipe of 37.5mm diameter the friction loss would be 0.38m per 100 length or 0.494 for 130m equivalent length.

Friction head loss = 0.494* (0.88) conversion factor = 0.435

Because the proposed system uses multiple openings, the friction loss is taken as 1/3 of the total friction loss; that is, 0.435/3= 0.145m. Thus the loss in the mains is within the 1.0 m/100m and a pipe of 37.5 mm diameter will be ideal for the design layout.

Laterals

A lateral is selected in such a way that the pressure difference from the proximate end to the last emitter does not exceed 10% of the normal operating head which in the present case is 4m. the maximum permissible variation in friction loss in the pipe is thus 4*10/50 = 0.8 m for as lateral of 50m length.

Irrigation system hydraulic modeling.

For this particular project, it was done using EPA net software. Pipe sizes were determined and this led to preparation of a pipe schedule for the system. This was through the following steps; setting the inputs for the model, modeling the system layout, assigning patterns, running the system and presentation of results.

Setting the inputs

The project default set up was done at this stage for the model. The included the abbreviations of the elements to be used in the network.

Table 3- 18 Prefix IDs for the network Elements (Source EPA net software)

Object	ID Prefix
Junctions	JN
Reservoirs	R
Tanks	TANK
Pipes	P
Pumps	PUMP
Valves	VALVE
Patterns	PTN
Curves	CURVE
ID Increment	1

Table 3-10 Hydraulic properties used in modeling the system (Source EPAnet model)

Option	Default Value
Flow Units	LPM
Headloss Formula	H-W
Specific Gravity	1
Relative Viscosity	1
Maximum Trials	40
Accuracy	0.001
If Unbalanced	Continue
Default Pattern	1
Demand Multiplier	1.0

System layout

Nodes representing junctions in the network were assigned their respective positions by inputting their coordinates from Arch GIS including their elevations and base demands. Base demands were calculated basing on the plant population of each block.

Nodes were connected by the links which represent pipes to come up with a network while assigning them different sizes.

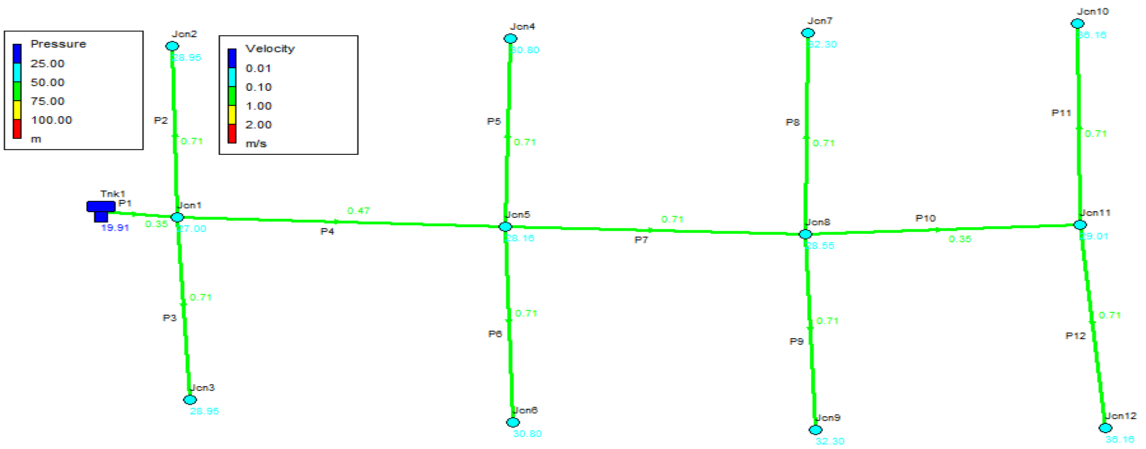


Figure 3-3: shows System Layout with the pressures and velocity in the pipe network during operation.(Source EPAnet model)

The pipe network characteristics in each pipe during the irrigation are summarized in the table 3-11 and 3-12 for 7:00-8:00hrs. Table 3-11 shows Diameter (mm), flow (litres per minute LPM) and velocity (m/s) while table 3-12 shows demand (LPM), head (m) and pressure (m) at the nodes.

Table 3-11 Pipe characteristics at 7:00 -8:00Hrs (Source EPAnet model)

Network Table - Links at 7:00 - 8:00Hrs			
Link ID	Diameter (mm)	Flow(LPM)	Velocity(m/s)
Pipe P2	25	20.83	0.71
Pipe P3	25	20.83	0.71
Pipe P4	75	124.98	0.47
Pipe P5	25	20.83	0.71
Pipe P6	25	20.83	0.71
Pipe P7	50	83.32	0.71
Pipe P8	25	20.83	0.71
Pipe P9	25	20.83	0.71
Pipe P10	50	41.66	0.35
Pipe P11	25	20.83	0.71
Pipe P12	25	20.83	0.71
Pipe P1	100	-166.64	0.35

Table 3-12 Pipe characteristics at 7:00 -8:00Hrs (Source EPAnet model)

Network Table - Nodes at 7:00 - 8:00Hrs			
Node ID	Demand (LPM)	Head (m)	Pressure (m)
Junc Jcn1	0	69.96	27.06
Junc Jcn2	20.83	69	29
Junc Jcn3	20.83	69	29
Junc Jcn4	20.83	68.85	30.85
Junc Jcn5	0	69.81	28.21
Junc Jcn6	20.83	68.85	30.85
Junc Jcn7	20.83	68.35	32.35
Junc Jcn8	0	69.31	28.61
Junc Jcn9	20.83	68.35	32.35
Junc Jcn10	20.83	68.21	36.21
Junc Jcn11	0	69.17	29.07
Junc Jcn12	20.83	68.21	36.21
Tank Tnk1	-166.64	69.96	19.96

The same pipe network and node characteristics were noted for the irrigation time of 18:00 to 19:00hrs.

4.CONCLUSIONS

The preliminary design of small scale irrigation system using water abstracted from Lake Kyoga was successfully done and included; a topographic survey, soil and water quality tests, pump and the pipework's for the system.

Since the water and soil parameters tested satisfy FAO Irrigation standards of Maize, it means that the plot (0.96ha = 2.37acres) and can be grown two times a year with a growing season of 125days.

The net irrigation water supply of at least 142.9 mm to cater top up and meet the required 800mm of actual crop water requirement for maize per crop per growing season.

CROPWAT 8.0 depends on estimates of climate and does not factor in the nature of soil conditions.

5. RECOMMENDATIONS

- All the developments about this project should be carried out with in the plot boundaries of the area to avoid wrangles that would arise from land disputes.
- More metrological stations should be place at least per district as in some cases data from a nearby station is not applicable to the area under consideration.
- PVC pipes should be used in the pipe network system since they are economical in terms of durability and cost.
- For security purposes to avoid vandalism a shelter for the pump should be provided at the point where it is to be positioned.

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