University of Nairobi

School of Engineering

DEPARTMENT OF GEOSPATIAL AND SPACE TECHNOLOGY

FOOD MAPPING; CASE STUDY OF TURKANA CENTRAL SUBCOUNTY

BY

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A Project submitted in partial fulfilment of the requirements for the Degree of Master of Science in Geographic Information Systems, in the Department of Geospatial and Space Technology of the University of Nairobi

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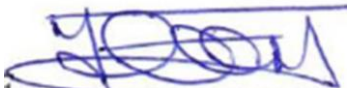
Declaration

I, **Ndonye Kyalo Mathew**, hereby declare that this project is my original work. To the best of my knowledge, the work presented here has not been presented for a degree in any other Institution of Higher Learning.

…… …**29/07/2022**……

Ndonye Kyalo Mathew Date

This project has been submitted for examination with our approval as university supervisor(s).



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MR. B. M. OKUMU Date

Acknowledgement

I would like to thank my Supervisor, Mr.Ben. M. Okumu who is my project supervisor for his help, his guidance and his continued support throughout the period of my project, without him this project would never have been a success.

I also feel indebted to my family, that being my Wife and children for their unwavering support, the ample time and encouragement which was very vital during this work and especially when things seemed tough.

Abstract

A food map is a visual representation of food related data on geographic location, at a given scale factor, existence of a food map gives a clear illustration at a glance of the situation and state of food in the area of interest.

Food mapping has proved to work in developed countries by providing inhabitants of this countries crucial information when needed.

The project aims to demonstrate distribution of food, water points, population and food producing activities in Turkana Central Subcounty.

The final product of the study will include food maps that will show irrigation schemes, water points, road networks, and a report on food in Turkana Central.

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List of Abbreviations

USDA ERS-United States Department of Agriculture economic research service
GIS-Geospatial information Systems.
CBPR-Community based participatory research
GPS-Global Positioning Systems
USA-United States of America
FAO-Food and Agricultural Organization
WFP-World Food Program
MDGS-Millenium Development Goals
AOI-Area Of Interest
NDMA-National drought management authority

CHAPTER 1: INTRODUCTION

1.1 Background

Turkana County is an arid area also consisting of a community that has been marginalized for a long time faces shortages in terms of food availability. Having lived in Turkana for a couple of years and have faced the same challenges the people of Turkana County face in terms of food availability, I decided to do a project that will help give a clear picture of the real situation on the ground and hence aid in giving guidelines to any person or organization that may want to help curb food shortage in the County, this project will also help decision-makers in making informed decisions in matters food security.

There are many dry places in the world just like Turkana or even worse but due to the will by the people, these places have been productive and, in the end, they end up producing more food than they can consume, a good example is Israel and Egypt. This realization led to the urge to want to be part of the change in our Kenyan arid lands and hence the best choice was Turkana County since it has been a hunger-stricken county for a long period of time.

Turkana County is the 2nd Largest County in the country after Marsabit County, there is availability of a large water table beneath its surface held by two aquifers, Turkana Basin and the Lotikipi basin that were discovered using satellites and radar, the aquifers are said to hold around 250 billion cubic meters of water, also the existence of Lake Turkana and Rivers Kerio and River Kawalase does provide substantial amount of water that can be used to improve livelihoods of the Turkana people.

Existence of these water bodies shows how much potential Turkana County has and if more effort is put on ensuring the County does produce enough food to feed its people and export surplus to the neighbouring counties and countries.

1.2 Problem Statement

Food scarcity in Turkana County has been a perennial problem throughout the years but there has never been methods, procedures or strategies to mitigate this issue of drought hence the idea to use GIS knowledge arose. GIS can help in development of (CISDP) County integrated strategic development plan which would work towards eliminating food shortage.

As the population of the country is growing immensely so is the population of Turkana County, hence increases in population lead increase in demand for food, need for food storage, and food supply in large quantities.
These food stores should be found in strategically located areas so that access to foodstuff is easy for those in need of the food, this is because recently there has been an increase in food consumption. Also, apart from food stores farms and food-producing activities should be encouraged in areas that can support these farming practices.
This document presents an understanding of what food mapping entails. It also contains the description of the assessment of food availability in Turkana as well as requirements to improve the state of food availability in Turkana County.
The document also contains the related research works that have already been done on food mapping including the findings and achievements.
Finally, it presents the food mapping gap identified from the already done research which creates the necessity to carry out further research.

Image 1 1 A picture taken in Turkana County showing a mother preparing food for her children during drought.

1.3 Objectives

1.3.1 Main Objective

Mapping food production and storage in Turkana Central subcounty.

1.3.2 Specific Objectives

1)Create a geospatial database that holds all food information together.

2)To map Sources of food in Turkana Central.

3)To create a map showing food transportation routes.

4) Map food storage facilities in Turkana Central.

1.4 Scope of work

The project involves creation of a geospatial database that holds food information for Turkana Central Subcounty, development of a document that gives a clear insight on the state of food security in Turkana Central at the moment and creation of maps showing farming practices and farm lands, transportation routes and advice on mitigation measures that will help in the fight against hunger.

1.5 Justification for the Study

This project findings will be a plus to the current food information in Turkana Central and the outcome will be disseminated to the general public, local authorities , county government of Turkana respective ministries and GIS practitioners so that it can guide, give more insights and be used in improving maters food security, development of farming policies and strategies together with the distribution of foods in Turkana Central Subcounty and the same can be applied to the whole County of Turkana.

To be able to understand well the economic, environmental systems and the complex social systems, mapping is very crucial and this is majorly mapping food access, food related disease prevalence, agricultural sustainability and food shed analysis.

Food mapping is also used in medicine and the field of human nutrition.

The product of this project will be made available to the County Government of Turkana ministry of Water irrigation and agriculture and Food and Agricultural Organization (FAO) hence will help in planning and decision making in matters related to food in Turkana.

The countries and counties bordering Turkana County would provide a good source of market to the surplus of foods if good planning is done and Turkana is made a food hub, this is because food insecurity has been an issue of concern to majority of the counties, and countries.

Recently a report released by OXFAM revealed that about 2.8 million Kenyans in 23 counties are in urgent need of food, even though the report did show that no one had lost their lives, it exposed how drought did continue to ravage most parts of the country and how there has been an increase from 2.1 million people who were starving last year around September to 3.1 million people. Among the most affected counties are Baringo, Isiolo, Mandera, Marsabit, Samburu, ***Turkana***, Wajir, Kilifi, Lamu, West Pokot, Garissa and Laikipia.

Oxfam warned that more than 28 million people across East Africa will face severe hunger if the expected rains do fail, and even if the rains do arrive, full recovery will be almost impossible unless urgent actions are taken immediately.

According to NDMA more than 600,000 children are acutely malnourished, NDMA attributed the food and nutrition insecurity to the December short rains, high cost of staple food, low livestock prices, the covid 19 pandemic and the effects of conflict and insecurity in Northern Kenya.

The government of Kenya according to its spokesman Col(rtd) Oguna has spent 1.2 billion this year on food aid and cash transfers for 380,000 people. However, what was notable was the fact that logistics of transporting the relief food would take about two thirds of the funds set aside for emergencies, lack of proper network coverage in some affected parts and theft of the relief food were some of the challenges.

CHAPTER 2: LITERATURE REVIEW

This article clearly shows that despite the global economic showdown, rise in the price of cereals almost a decade ago and there being an increase in population by almost 2 billion, there has been a steady decrease in the number of people suffering malnourishment globally and this numbers have gone down by more than two hundred million from the year 1990, this is majorly due to the increased willingness and commitment to act against hunger. (United Nations World Food Programme, 2017)

Previous studies have mapped:

-Cost of foodstuffs.

-Proximity of food sources to human settlements.

-Foodstuff quality.

-Product diversity.

-Foodstuff variety.

-Availability of the foodstuff and

- Nutrition.

Recently efforts that were aimed at ensuring hunger targets according to Millennium Development Goal (MDG) are achieved were halted, this is simply because ,72 out of 129 countries that were being monitored have achieved the MDG hunger target and currently there has been an improvement seen from 1990. Earlier on,23.3 percent of the world population was undernourished but currently only 13 percent is. (Alexandratos, 2012)

Food mapping will help provide a great visual display of geographic data related to food, this display allows the user of the map to be able to detect qualitative spatial patterns, detecting of this pattern might have seemed impossible if an analyst or user used a different or traditional form of data analysis. (Kaiser, 2017)

But we are still not where we want to be since almost 795 million people still face hunger, this shows that one out of nine persons worldwide are at a risk. If we want to achieve zero hunger and make hunger history then we ought to do more. (Blesh, 2019)

Food being a basic need leads to big money for those who practice it in large scale, the gap between the malnourished and the nourished increases as the gap between the rich and the poor does increase. Due to increase in demand for food, this has led to pressures hence most people have embraced the issue of genetically engineered food crops together with use of chemical fertilizers. (Himes, 2002)

In the past, the Cuban association of Agriculture and forestry technicians has used mapping as a tool to identify maps in Havanna, Cuban ministry of agriculture too does identify where food is needed and does compare to land base for agricultural production with the aid of mapping hence, they are able to set policies on what foods to be grown where and when. (Clausen, 2007)

Maps have in the past been created by various community scholars especially in the field of geography, organizations, and officials from the field of public health, this map did aid in understanding disparities in food environments by the aid of different mapping methodologies.

Academic disciplines in the fields of physical planning, epidemiology, public health and nutrition together with geography related disciplines do inform future research and highlight future disparities by use of mapping software. (Juarez, 2014)

Food maps have previously been created by international aid organizations hence help in providing food related disparities and a visual representation of food systems which residents and donors together with policy makers have previously used for educational purposes, in creation of equitable food policies and in awareness creation, this in turn leads to food safety, animal welfare, food sovereignty, food security and fair trade. (Schanbacher, 2010)

In the year 2009, USDA ERS did release a report that examined accessibility to healthy foods and the outcome of the report was to provide recommendations and policies for the local and national governments. (Sohi, 2014)

Illustration of findings has previously been done by the aid of tables and charts together with GIS mapping techniques.

In California, Quinn, forester and Ghirardelli did employ GIS in surveying 473 grocery stores and 68 low-income neighbourhoods to find out the percentage of residents that had access to fresh produce and grocery stores. (Sweeney, 2016)

Previous researchers have used Community based participatory research (CBPR) whereby the members of the community have aided in determining access to different food outlets within different class categories of people.

In Philadelphia, Kremer and DE Liberty did estimate how productive in terms of food generation that urban lands can be and, in the end, they did discover that the city of Philadelphia had a vast potential in food production, these results did originate from use of data on demography, use of GIS mapping tools and Remote Sensing (RS). (Kremer, 2016)

In 2010, Agyeman and McEntee did contribute to positive growth of the literature on food deserts, this they achieved by identifying places where the low-income earners in the society lived, this are people who do not have the luxury to choose what to have in their diets hence whatever is available is what they consume. (McEntee, 2010)

The most prevalent topics include, food security, food justice and food access, the reason for this topic being so common is because of there being an increase in income inequality which leads to inequality in accessing healthy foodstuffs. This imbalance leads to negative effect on population growth due to poor nutrition which in turn impacts negatively on health matters.

In the year 2013, Liu and Zhang from the republic of China while trying to handle the issues of food insecurity in their country did develop methods that were used to measure land use sustainability. They did study factors determining food accessibility, they also examined the accessibility of foodstuffs by looking at outlets of specific foods while comparing them to race together with income, later on statistical analysis was done on the patterns formed. (Fan, 2019)

In the year 2011, DE liberty and Kremer from Philadelphia did examine study the food systems of Philadelphia a study that did measure the food production potential land space in an urban setting by combining both GIS and Remote sensing. (Kremer P. &., 2011)

In the year 2008, Ontario. Lefer et al from London did evaluation and mapping of food and exercise related resources near a health centre by utilizing Google earth engine mapping tool. In the same year, Peters et.al did a theoretical food shed potential for urban centres in the state of New York by utilizing land cover data, soil data, population data, urban areas recommendation and dietary recommendations. In the same year Lefer et al did utilize google earth engine being a low-cost mapping software in a participatory community mapping project whereby measurement of exercise outlets was done in New York a place called Bronx, by looking at the varieties of different foodstuffs and their quality. (Amani, 2019)

In the year 2011, Bar-Yam, Widener, and Metcalf all from New York did examine availability of healthy foods, the temporal variations in the nature of food availability, accessibility in terms of different vegetables and fruits based on different seasons in the City of New York a place called Buffalo. This in turn led to informing policy makers in USA on how to handle issues relating to access of healthy foodstuffs. (Widener, 2013)

In the year 2012 Lovel and Taylor from Chicago also did use google earth engine to analyse images, map and identify spaces that are meant for production of food in Chicago. During this same year, Smith and Hwang did show that with ease of dissemination and with minimum cost a framework that utilizes open-source mapping software can be used to access and map food security. Also, a map showing food expenditure at home versus away from home in USA was created. (Pulighe, 2016)

In previous studies and researches most study areas have been previously been determined by the percentage of available data and existing time frame available, food mapping does aid in planning and creation of policies. Food consumption, climate change, hunger, food quality, and food environment studies have previously served to inform and inspire specific missions such as emphasizing issues as poverty or hunger.

The topic that has been explored most on food matters by researchers is food access especially at the neighbourhood levels. Food security and food access studies did lead to implications on policies for food safety, equity and health, this is because food safety policies can easily utilize GIS.

Canadians too aren't left behind when it comes to matters food mapping , this is because in the previous years as in the year 2012, Ishigaki did produce a map showing facts on food and crops and food related matters in Canada which was friendly to users and one would just need to move the cursor on the map and click on a certain location in the map and all food related information to that geographic place would be displayed to them and factors that may impact accessibility to this foods rather than proximity. (Sweeney G. M., 2016)

2.1 Food

According to John Hopkins Medicine, and food diet, our bodies are supposed to feed or consume specific diets to help avoid complications that may arise due to poor diets, some of the complications may arise include, diarrhoea, constipation, bloating of the stomach, or cramping. But due to several factors, among them inability to access this diet due to high poverty or inaccessibility of this foodstuffs in some geographic locations, people have to get used and know how to survive without these foods, also the shortage of dieticians is another challenge.

For a healthy and balanced diet, there should be
-carbohydrates from vegetables and fruits, milk which also has calcium, vitamin A and B12, potassium, magnesium, phosphorus and iodine
-proteins from fish, poultry, beans and nuts, fish has vitamin D, it improves vision and eye health
-Starch whole grains such as wheat, barley, brown rice, quinoa, and oats
-Vitamins from vegetables and kale, includes vitamins A, C and K kales also have some proteins and calcium.

2.2 Hunger

Hunger is a state that leads to a person not being able to willingly access a balanced diet due to weak financial muscles or also being unable due to physical reasons. Hunger has been a global issue that if not handled might lead to catastrophic results, like in Lebanon recently according to Aljazeera, at least 2 million Lebanese are suffering from malnutrition, this number is almost half the population,
Similarly in Kenya, there has been a rise in food prices in the recent past, a problem that is being attributed to the war between Russia and Ukraine

2.3 Food mapping definition

There is no specific definition of what is food mapping. However, several scholars have given food mapping definitions based on their understanding.
Food mapping entails displaying on map food sources or outlets about human settlements according to (Marte 2007)
To succeed in mapping, we use GIS software that can analyse food matters in different ways hence giving the scholar or researcher an edge in terms of analysis.
During food mapping, the mapping of grocery stores and land parcels that can be devoted to agriculture are the main assets that will be considered in the map.

Food sources are found in nearly every populated area in terms of hotels, food shops, and food stores. A food store can be in terms of a silo, which is a large metallic store for storing agricultural produce that is grains.
The Project is to help curb hunger in Turkana County.

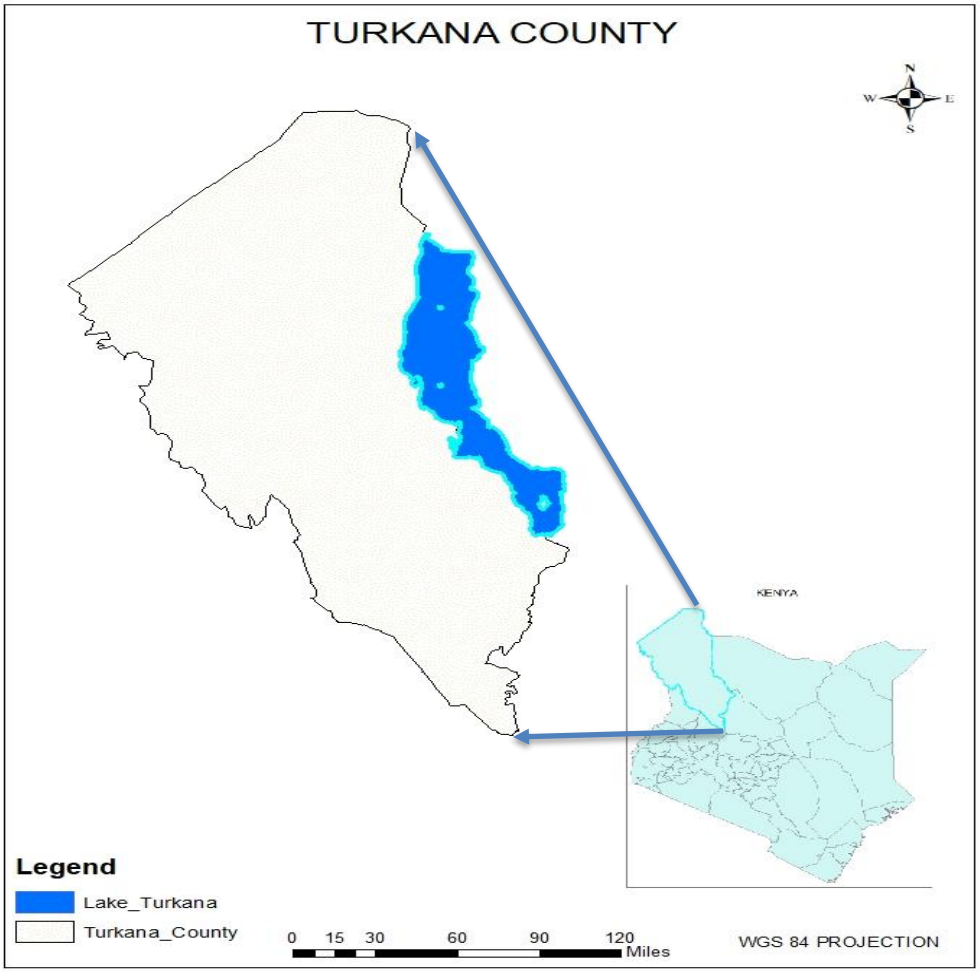


Figure 1 1 *Turkana County shown in Kenyan Context*

If the current generation does utilize their knowledge and skills together with the available resources and the great intellectual potential available in the country then Turkana people will not have to depend on imported foods and food aids to survive.

Note: Currently, 70% of the economic livelihood in Turkana is livestock keeping,20% is crop production and this entails subsistent farming,5% is fishing whereas the other 5% remaining do depend on other sources of livelihoods such as basketry and bead making.

Most of the neighbouring communities around Turkana are hostile to the people of Turkana and this is due to the banditry that is rampant as most of this communities are also pastoralists and livestock theft has become a norm.

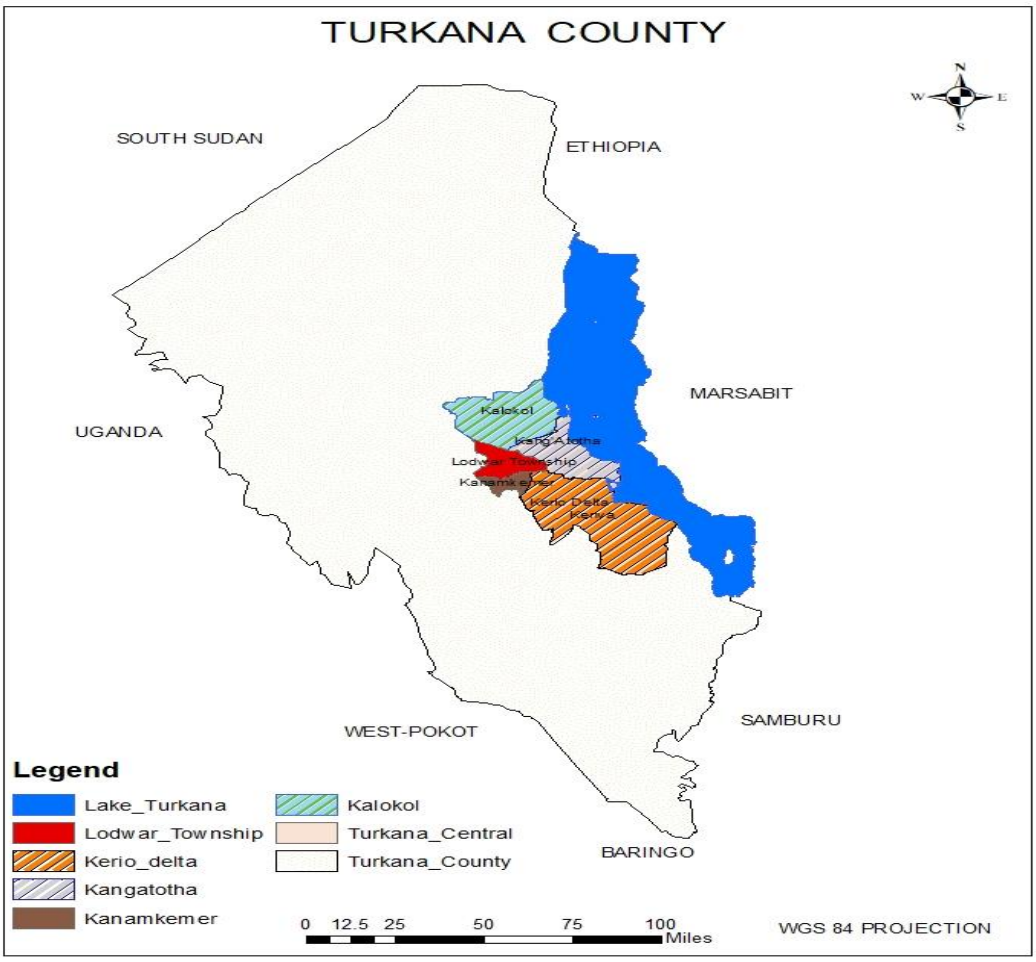


Figure 1 2 *Turkana County showing the area of Sturdy and the neighbours of Turkana.*

Turkana County is bordered by Three countries Uganda to the West, South Sudan to the North and Ethiopia to the North, the county of Turkana also borders four counties namely, West Pokot County and Baringo County to the South and Samburu and Counties to the south while Marsabit county is to the East.

This food mapping project will lead to a self-sufficient and food reliant County of Turkana if the proposed measures at the end of the project are implemented and used to guide decision makers on decision making in matters pertaining food.

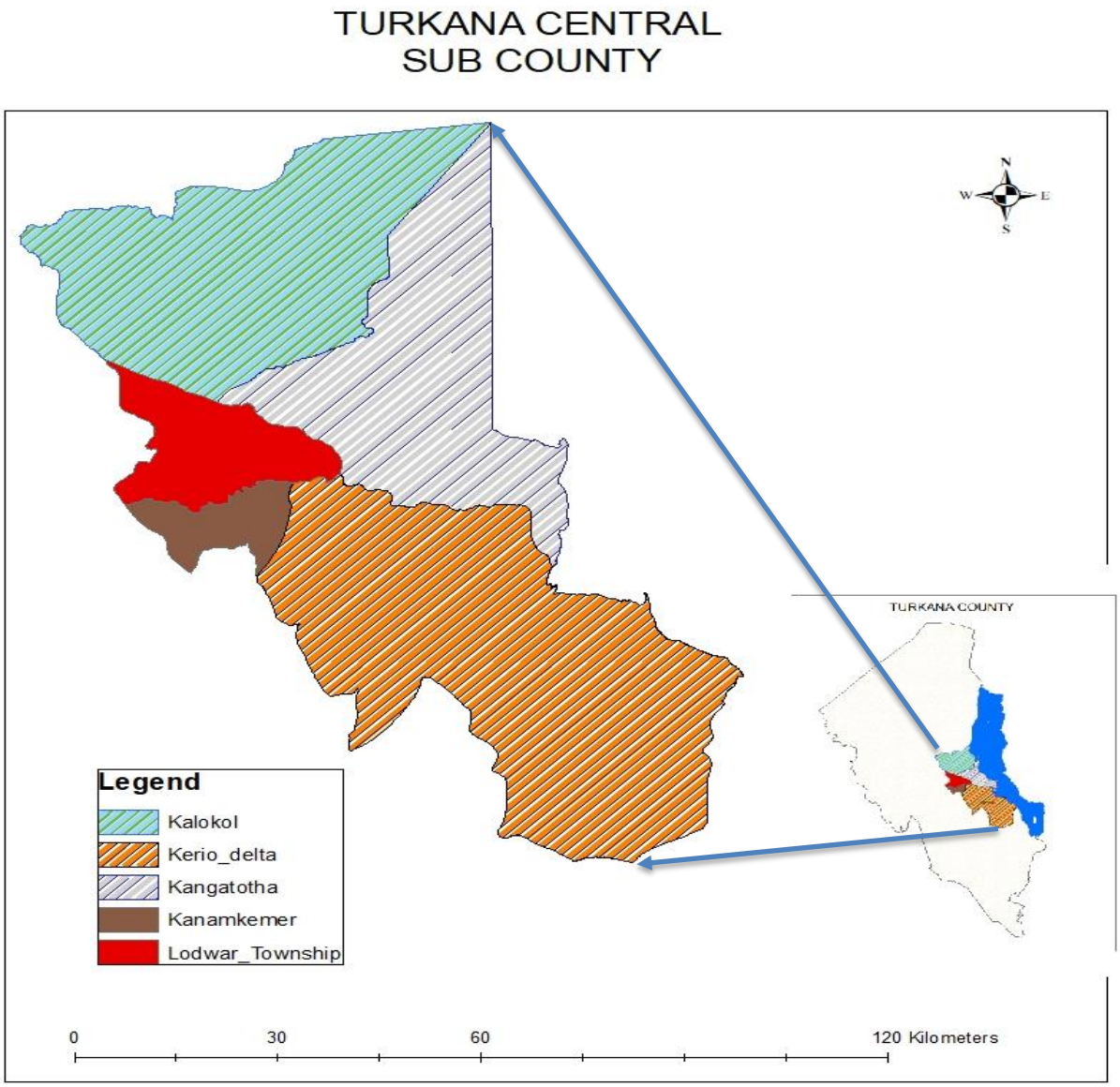


Figure 1 3 Turkana Central Sub County shown in Turkana County Context

The case study for the project is Turkana Central Subcounty, a subcounty with Five (5) wards, each ward having different potential in terms of foods that can be produced from it.

The reason for the study of the five (5) wards and not one ward is due to different consumer behaviour and preferences, which is greatly influenced by the type of food that can be accessed.

CHAPTER 3: THEORETICAL FRAMEWORK

3.1 Methodology

Identification of the datasets to be used for the project was done by consultation with the project supervisor and a list of all the data needed was penned down based on the need of each dataset.

Data that is attributed to some geographic location was classified as spatial datasets, that is data with coordinates, whereas data that had no coordinates was classified as non-spatial data. Both these datasets were combined and stored together for the purpose of the project.

Processing of the data was done, where each data was processed so that it meets the threshold and standards needed for a quality work. Some of the processing techniques included, reprojecting and conversion of the datasets from different coordinate forms to a uniform coordinate system. Reprojecting all datasets to one projection is key since having data in different projections would lead to bad overlays, conversion of the datasets did help in ensuring the data is converted to workable formats hence ease in analysis and preparation of maps.

The data collected from unstructured interviews was edited so as to be fit for inception into the project.

The data correctness was looked at and if it did qualify, a geodatabase and maps were created, analysis was then done and results produced.

Below is a diagram showing the methodology that will be used to ensure success of the project.

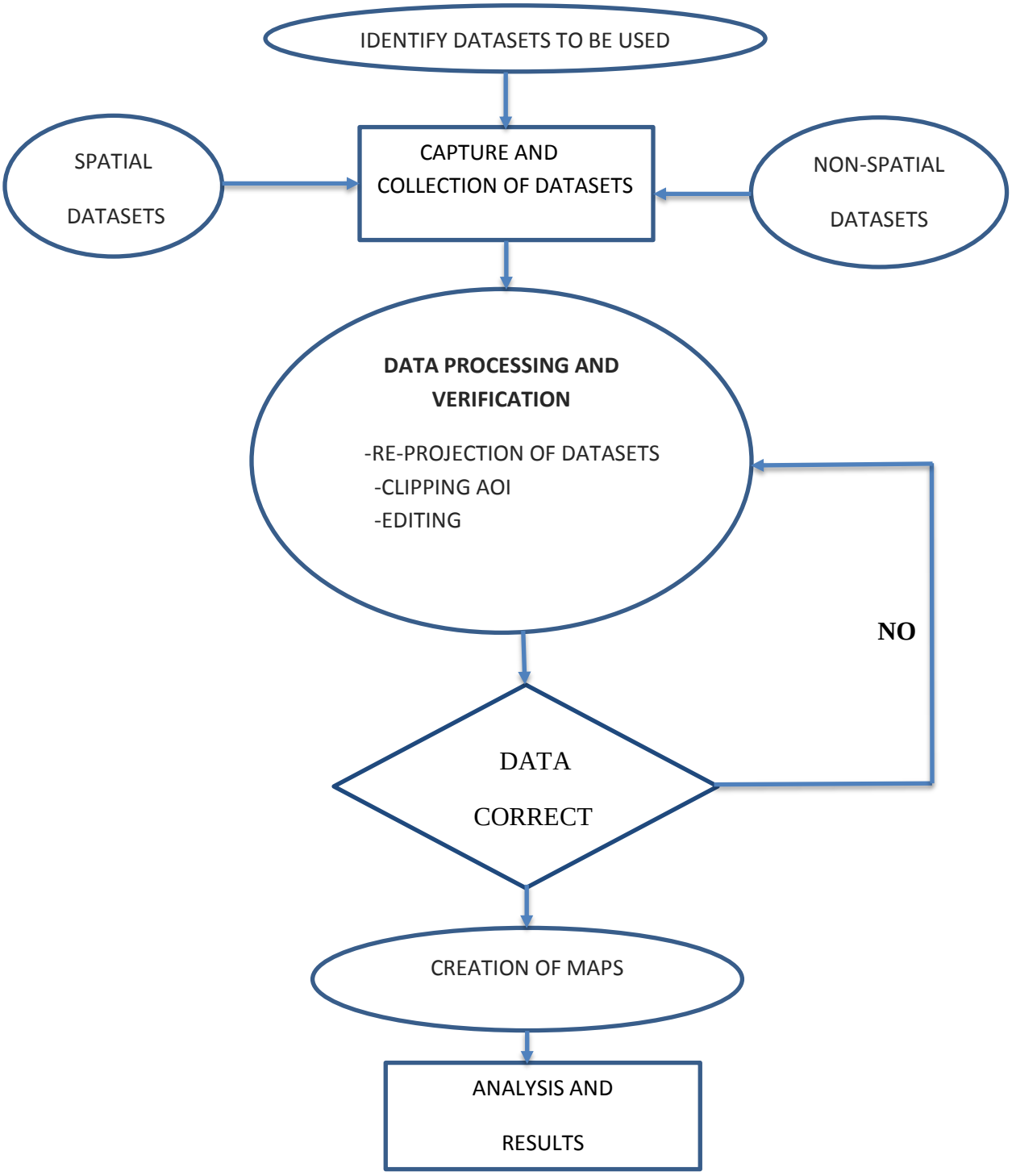


Figure 1 4 Methodology

3.2 Sources of Data

Data to be used will be from various sources as shown in the table below

DATA TYPE	DATA SOURCE
-Transport data	-Ministry of roads and public works
- Population data	- Kenya National Bureau of Statistics (KNBS)
- Water points	- Ministry of water
- Irrigation schemes	- Ministry of agriculture
- Fishing sites	- Ministry of fisheries (Turkana County)
- Satellite image	-Regional Centre for Mapping and Resource Development (RCMRD)
- Weather data	- Meteorological department
NB/ Satellite images are for land use purposes and to aid in doing ground truthing	

Table 1 Data types and Sources

3.2.1 Primary Data

Collected primary data was processed and compiled then archived so that it does help someone else in future, that being an individual or an organization /institution. Collection of this type of data was via interviews with the target population and the authority that is the respective ministries as the ministry of water irrigation and agriculture, ministry of pastoralism, National Drought Management Authority (NDMA), Global Positioning System (GPS) coordinates, and Satellite images.

3.2.2 Secondary Data

Secondary data collected did provide background information on the food situation in the sub-county of Turkana Central, this data is available in documented writings on food mapping together with previous food mapping reports.

3.3 Data Collection methods

3.3.1 Interviews

Some of the information that was used in the project was obtained from interviewing the local authority and those in positions to know about food matters in Turkana County hence help in creating measures to help solve issue of food insecurity in the region. The interviews were unstructured and orally administered.

Both ministries of agriculture and pastoralism will give insights on plant and animal farming in the county.

3.3.2 Observation

Observation was used to generate a lot of detail that was used in the project, Observation of features as irrigation schemes on the ground and observation of aerial images too did give insights that would never be obtained from imagination.

3.4 Software and Hardware used

ArcMap version 10.7

- ✓ This will be used to:

- ✓ Create a geodatabase
- ✓ Geotag photos to their location in the map.
- ✓ Create maps.
- ✓ Reproject datasets.
- ✓ Clipping AOI.
- ✓ Google Earth Engine

This will be used to:

- ✓ Generate kml files that can be converted to shapefiles.
- ✓ Visualize sites that cannot be accessed physically.
- ✓ Microsoft word

This will be used to:

- ✓ Compile and prepare the project report

Microsoft PowerPoint.

This will be used to:

- ✓ Compile and prepare the presentation.

Computer HP Core I5

This will be used to:

- ✓ Host Software's to be used in doing the project.

Hp printer

This will be used to:

- ✓ Print hard copy documents after project completion

3.5 Approaches to research

This are sequence of events on how they will take place one after another or systematically so as to lead to solution of a problem at hand. For our case it will help come out with potential food production areas and food location sites in the Turkana Central sub-county.

3.6 STEPS

Five (5) major steps were taken from addition of data to coming up with final product of the project.

I. Addition of data
II. Defining Projection
III. Creating a geodatabase
IV. Creation of features and editing
V. Geotagging images.
VI. Preparation of final maps.

3.6.1 Adding Data

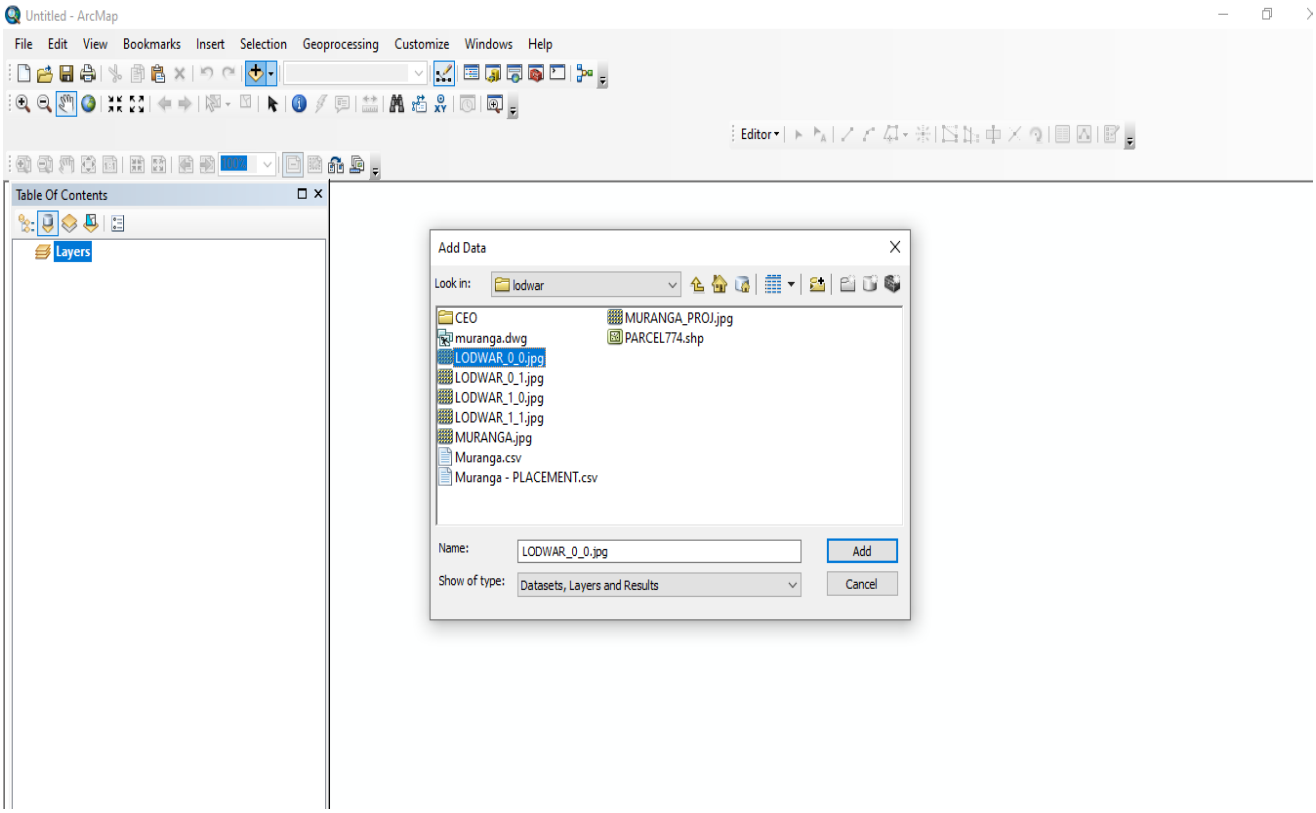


Image 1 2 Adding data to ArcMap display window

Data that was used to ensure success of the project was added to ArcMap by clicking the add tab on the ArcMap display window. The above snap shot shows raster data being added to the display window. However, all data sets be it vector or raster are added in the same way for them to appear in the display window.

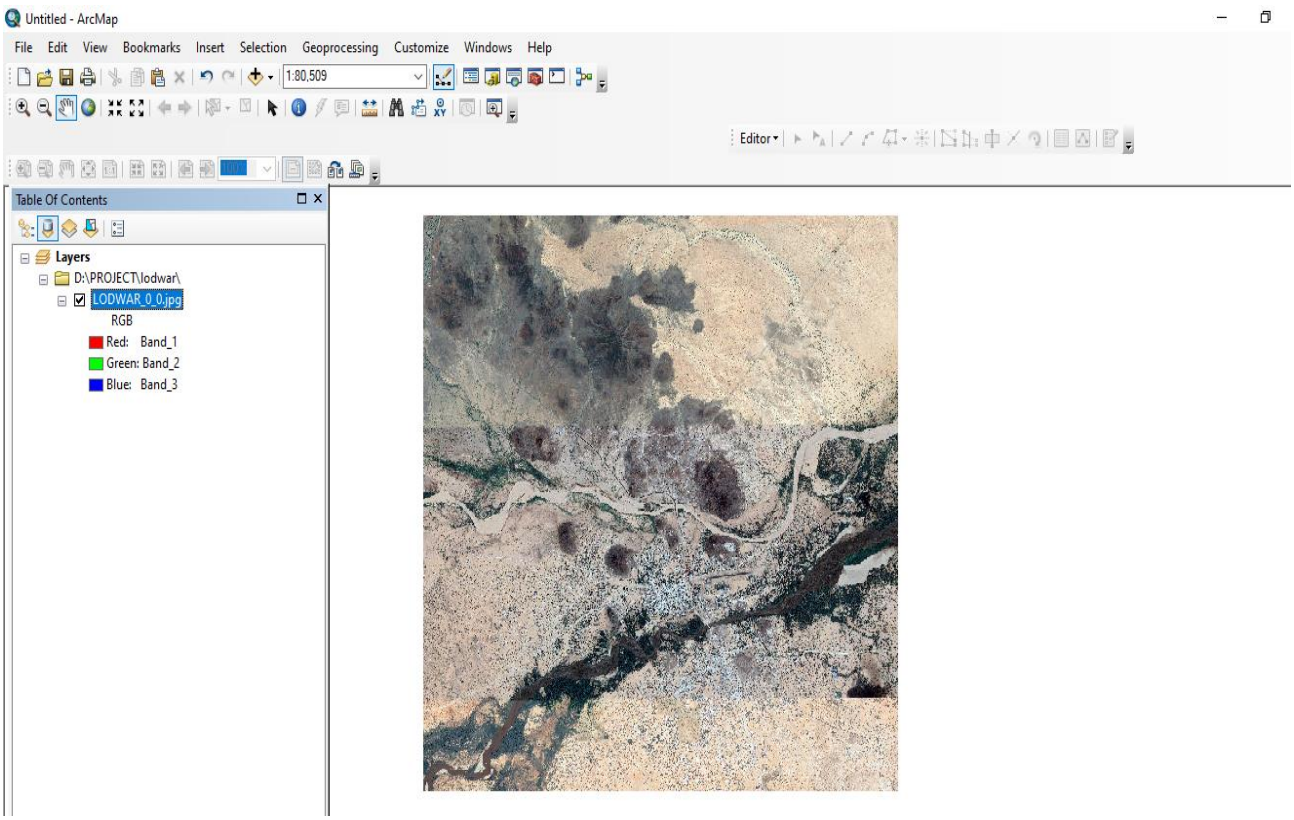


Image 1 3 Display of the raster dataset added used in Arc Map for digitizing AOI

For the data to be in the correct position georeferencing was done, the process of georeferencing entailed choosing a minimum of four known pints with known coordinate systems and tying the points to the coordinate systems hence ensured that any work done later on would show the data prepared in its correct location on the ground. The image of Lodwar Township was obtained from geoeye satellite and the reason for choosing lodwar Township is because throughout Turkana Central only Lodwar Township has many developments, most of the other parts of Turkana central are bare land mostly undeveloped, this is evident from images obtained from google earth engine.

However, adding XYZ data from excel is slightly different, some data sets have the raw data collected as points containing coordinates that is eastings and northings, for this type of data to be displayed in ArcMap software it has to be converted to csv comma delimited.

For the case of irrigation schemes the data available was given as northings and eastings hence an excel sheet was created.

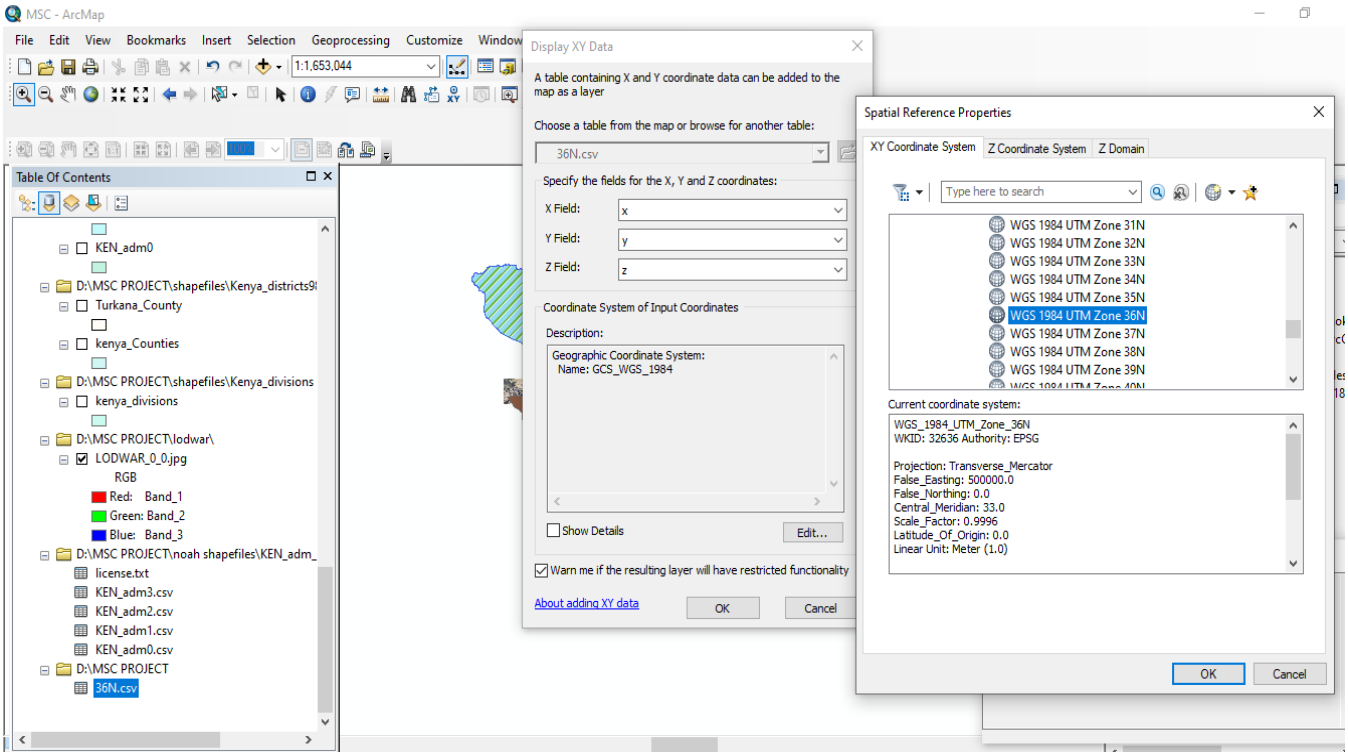


Image 1 4 Addition of XY datasets from excel to ArcMap display

The data in csv comma delimited excel format was added just the normal way the way any data would be added to ArcMap by clicking the add tab at the panel.

The added data only appears on the table of contents but not in the display screen, the data was then right clicked and, in the drop, down list that appeared, display XY data was selected.

The table that appeared was filled with x for X field and display y for Y field, then the projection was chosen, like this case the irrigation schemes were falling in two different zones that being zone 37N and zone 36N.Hence that was made clear during setting up of the projection parameters, otherwise some points would not be visible.

Note.

Irrigation schemes Naoros,Nadoto,Nakoret,Kangirisae,Nangitony and Ngimuria fall in zone 37 North,while Irrigation Schemes Kakwanyang and Napuu do fall in zone 36N.

3.6.2 Defining Projection

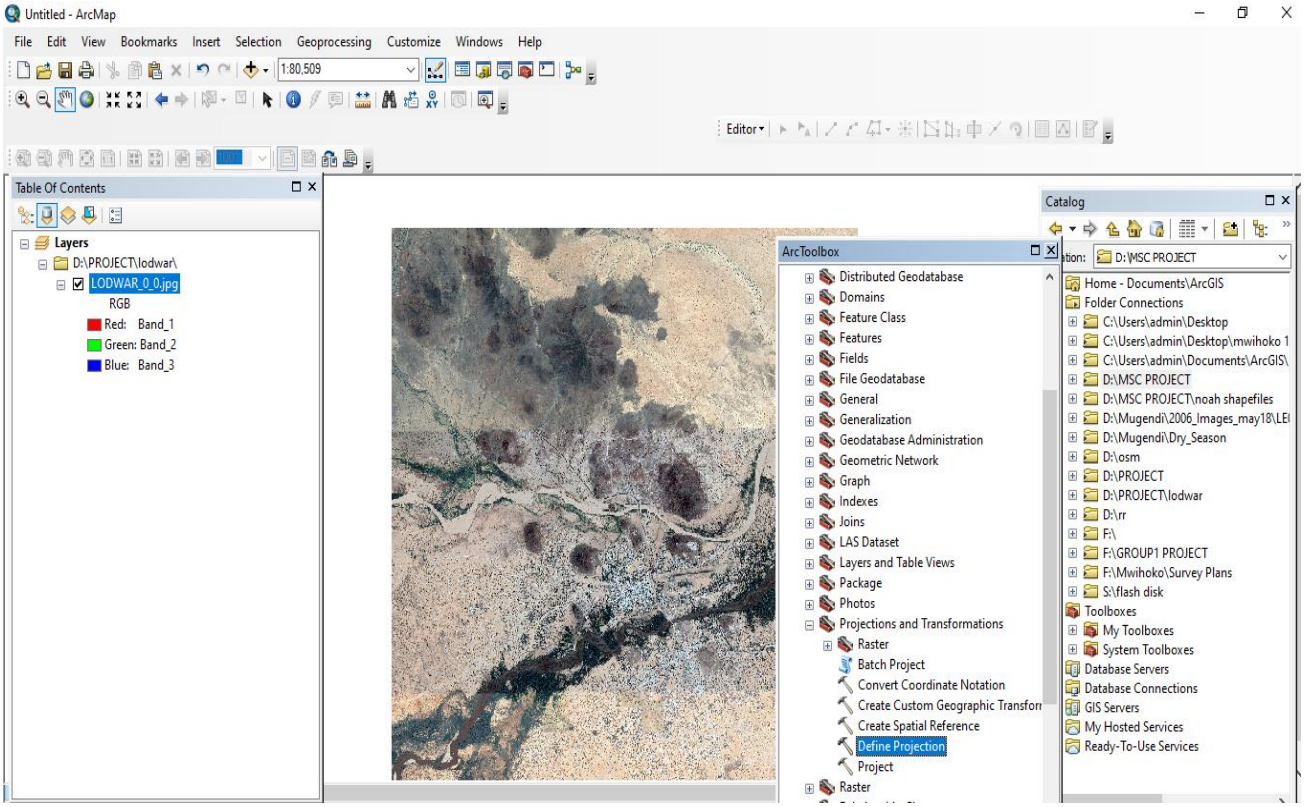


Image 1 5 Defining Projection

Projection of all datasets loaded into ArcMap had to be defined before working on anything, this was to help ensure that during the progress of the project there are no hitches due to datasets being in different projections. For one to access the projection tab ,in Arc toolbox open projections and transformations, then select define projection, then the table that appeared was filled whereby input data or feature class was selected from the drop down panel, the output dataset or feature class tab was filled with the location that our datasets that are projected will be stored, and the output dataset was selected, that being the coordinate system we want to convert our data to, for this case it was Arc 1960 UTM Zone 37N.This is because the area of study falls in Zone 37 North.

Below is a continuation of how reprojection was achieved.

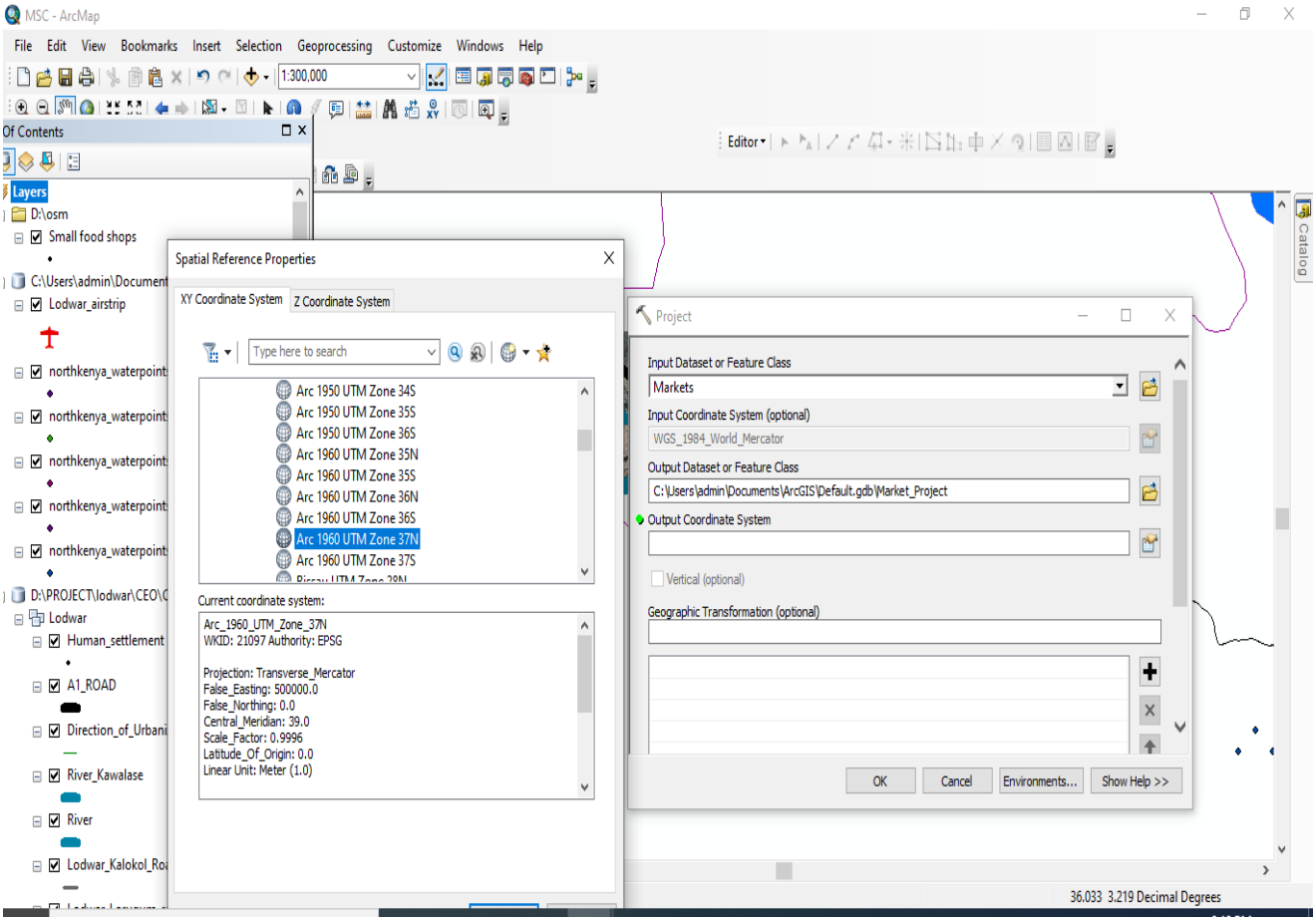


Image 1 6 Defining Projection Continuation

All datasets, that is the satellite imagery and the shapefiles were reprojected one at a time and as seen on the left-hand side of the snapped image the datasets were many but had to be done for seamlessness of the data.

3.6.3 Creation of Geodatabase

It is in a geodatabase that data and shapefiles will be stored, in this case food data.

To be able to successfully create a geodatabase, at the catalogue window a new folder is created and named. Right click on the created folder and select new so as to create a new geodatabase.

Right click on the created file geodatabase and select new and hence create a new feature dataset.

Projection is then chosen at the new feature dataset window.

In the new feature class, a field name is added based on what is to be detailed in the data, example of this case the table already has object id and shape that are already in the field name column.

The object id will hold the unique code for the object, whereas the shape will hold the geometry datatype.

Based on this project, the below field names were added.

In charge- showing who is in charge, such as the community members or the local authority.

Products -showing the name and type of the product distinguishing it from others

The capacity-showing the quantity in terms of numbers.

The picture -showing a pictorial representation of the feature in discussion or the image of the facility.

Fields created in the field name column were filled by typing details in it, then the datatype was chosen as text or float, but for the case of pictures then raster datatype was selected so that it permits loading of pictures into the table.

Below is a snapshot of the above explanation.

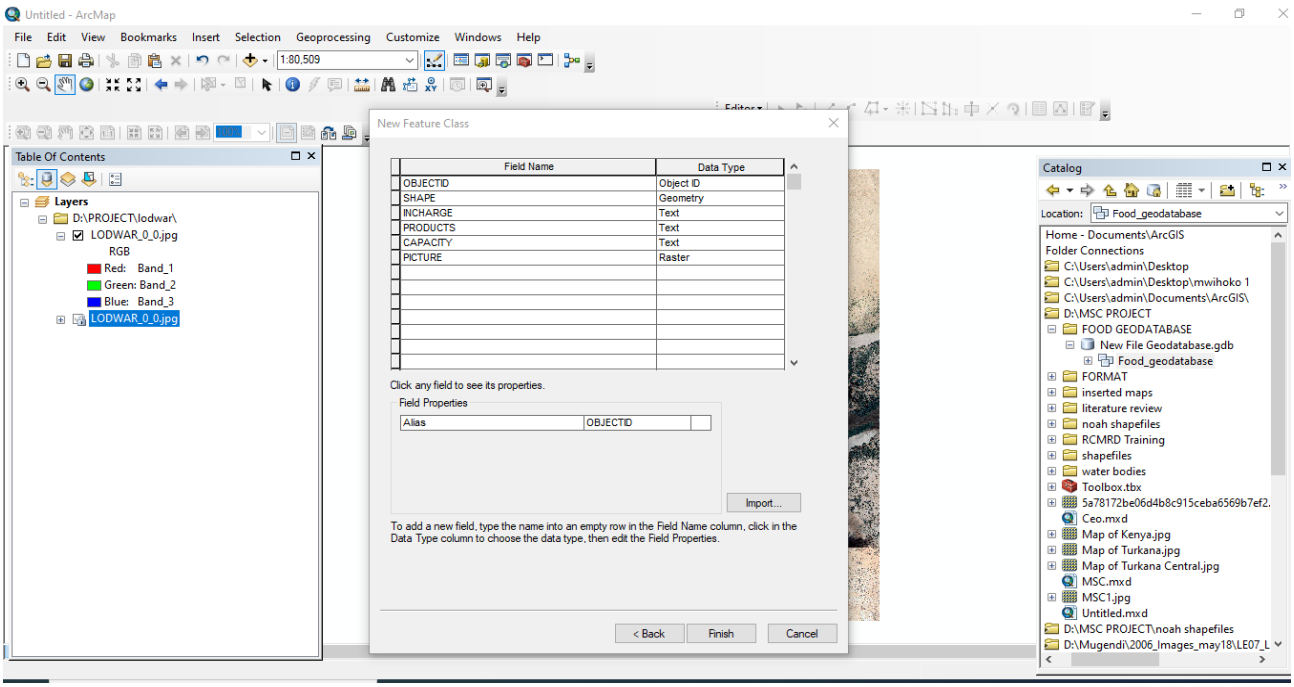


Image 1 7 Creation of Geodatabase

In the datatype:

-Short integer is used to portray whole numbers
-Long integer is for datatypes that that have got large range
-For numbers with decimals, float is used
-Blob is for very large objects, numbers and datatypes
-Guid is for unique identification, it is globally recognised and developed by algorithm
-Raster is for images whereas text is for words

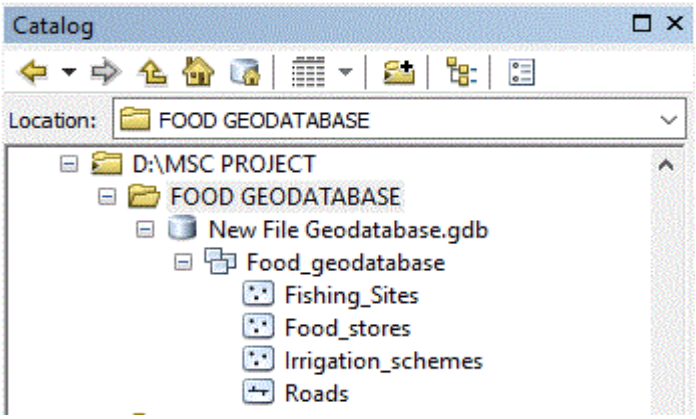


Image 1 8 A snapshot of the geodatabase from the catalog window

3.6.4 Creating features and editing

After the geodatabase is complete, the editing tab is clicked and start editing is activated.

The feature to be edited is selected from the create feature drop down menu in the editing window, and the action completed by clicking okey.

Depending on the feature to be created, point features are represented by points, such as water points, rivers and roads are represented by linework data while spatial areas are represented by polygon features.

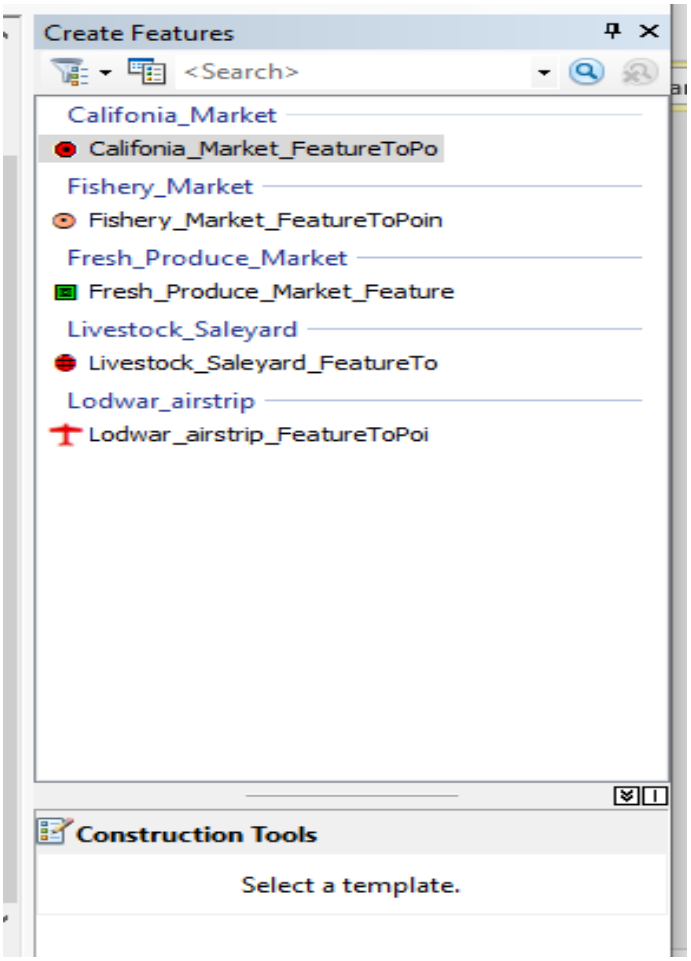


Image 1 9 Create features task bar

The edited features would later on appear in the table of contents where by changes can be made in the table of contents by right clicking at the feature then changing its appearance in terms of shape and colour.

To edit the names, at the table of contents a feature was clicked and renamed, or alternatively after clicking at the features its properties in the drop-down tab was clicked and the name edited to the desired values.

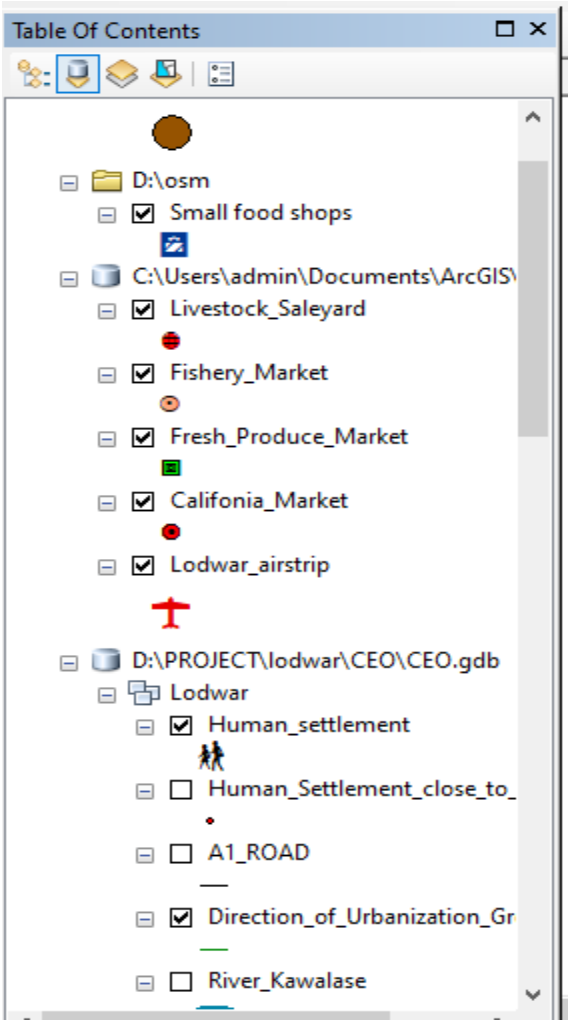


Image 1 10 Table of Contents task bar

3.6.5 Geotagging Images

Below is a table of content with geocoded images, the table of contents belongs to food related markets in Turkana Central.

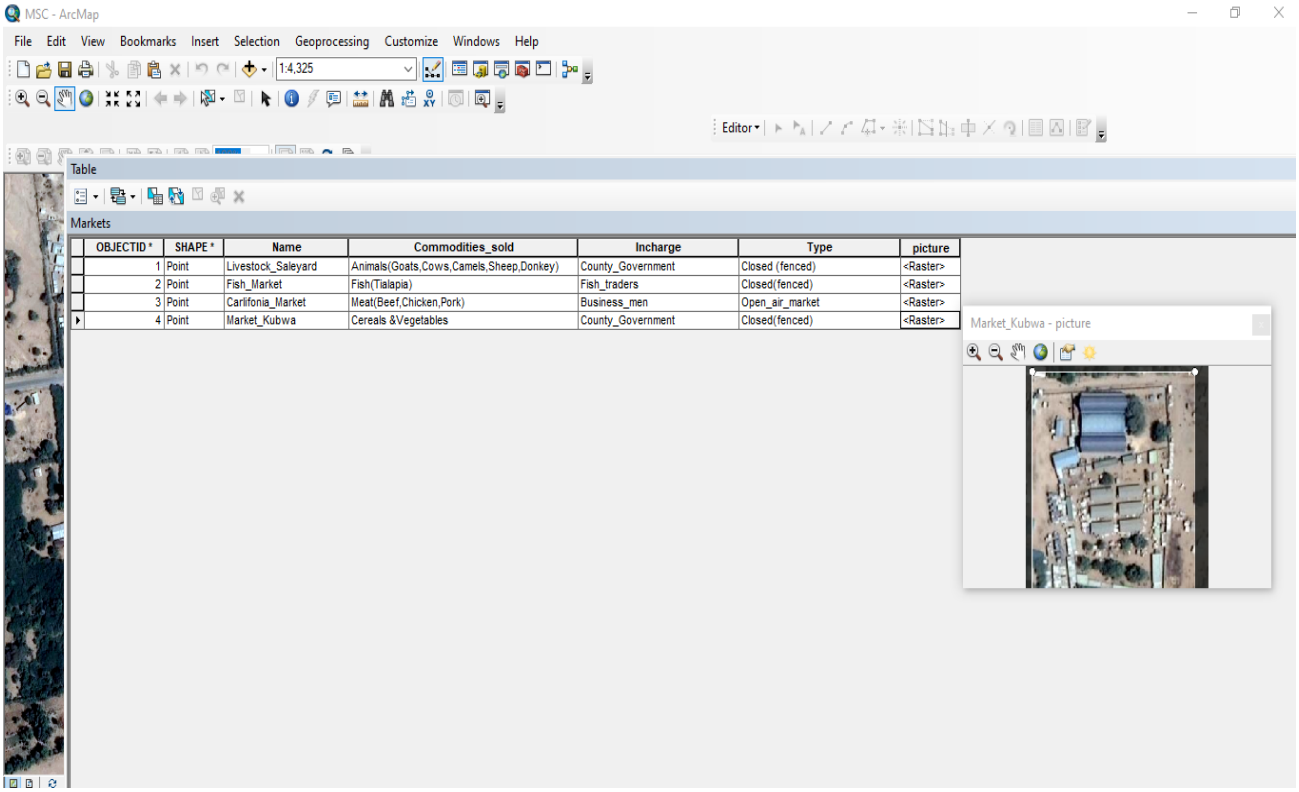


Image 1 11 Geotagged image of market Kubwa

How geo tagging was achieved:

The first steps before geotagging are creation of a geodatabase which had earlier on been explained.

Click on catalogue window and create a new folder.
Click on add + new and select personal geodatabase after which a name is given.
Click on add +new feature class.

Next was clicked until a table with ***new feature class*** did appear, a name was added on the table say ***picture /image*** and text was selected then the field ***add pictures*** was clicked in the table and ***raster*** was selected since images can only be loaded as raster, a picture was then chosen from the computer and then the process completed by clicking finish and edits were saved.

3.6.6 Preparation of final maps

After all features have been created and edited, these features do appear in the data view of the ArcMap, hence to create the final map these features were displayed in the layout view.

For a map to be considered standard, it has to have some basics such as the Title, the legend, the north arrow, the scale and in some instances the projection, grid, author and any other additional information the author wants to portray to the users of the map.

During preparation of the final maps most of these features were obtained from the insert tab.

During inserting of the legend, features not needed were eliminated and the order of appearance of the legend was altered to be more appealing to the user. This was archived by the use of the legend wizard.

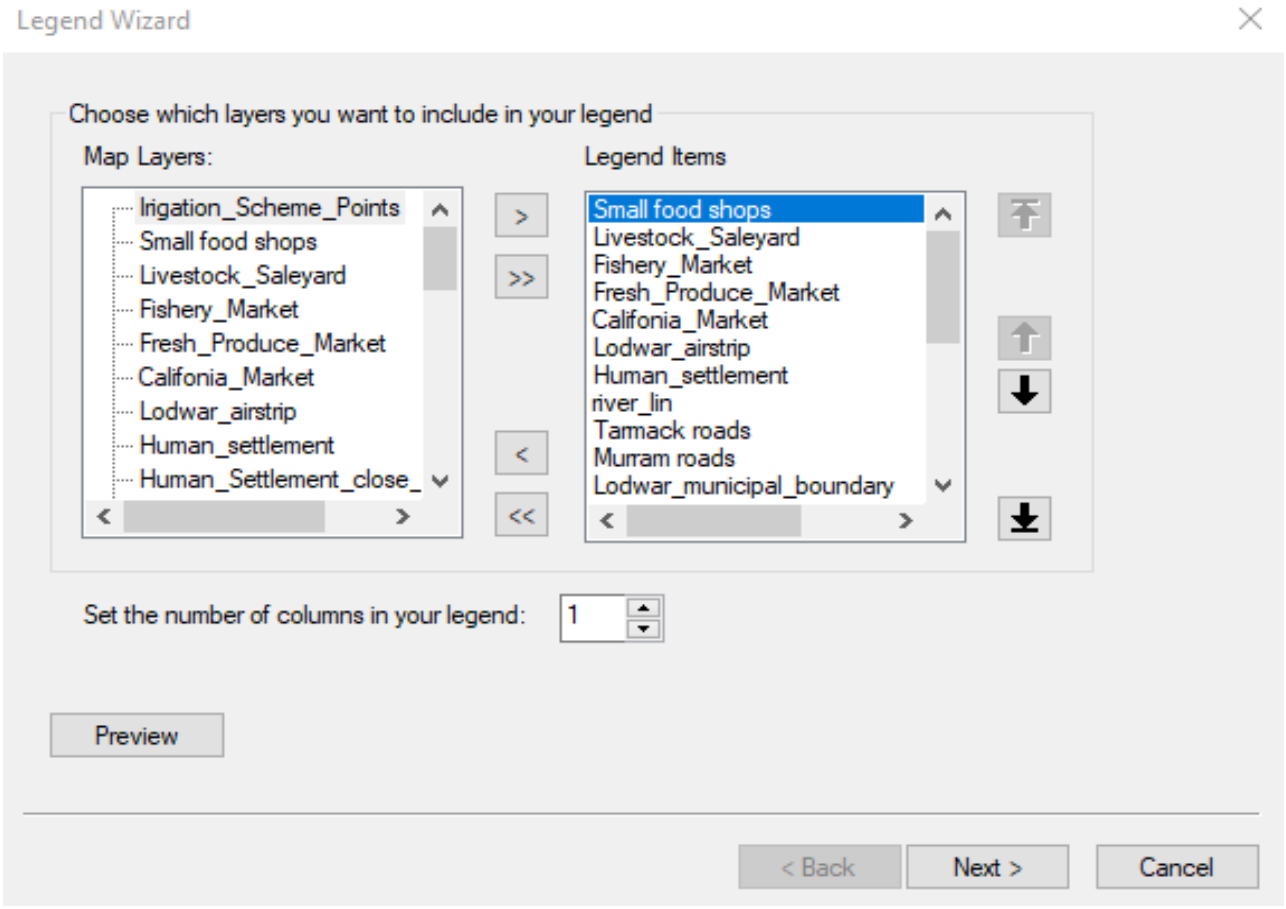


Image 1 12 Snap shot of how legend was prepared

CHAPTER 4: RESULTS AND ANALYSIS

4.1 Analysis of the Data

Analysis of data was done visually and what could not be analysed by looking at its analysis was achieved by use of ARCMAP software. Some of the findings after completion of analysis included effects of irrigation farming on the livelihoods of communities living around the irrigation schemes, the rate of adoption of farming in Turkana Central, challenges facing adoption of irrigation farming, measures were suggested, measures that if put in place would enhance irrigation in Turkana Central sub-county. Data presentation was done through, graphs and pie charts.

4.2 Results of Creation of food maps

Food sources, food storage facilities and food distribution means are all that revolves around food from production to consumption.

Hence maps showing food sources such as irrigation schemes, food storage facilities and transportation routes were created.

Lodwar Town

Map of Lodwar town showing food markets and storage facilities and their relationship to transport and human settlements.

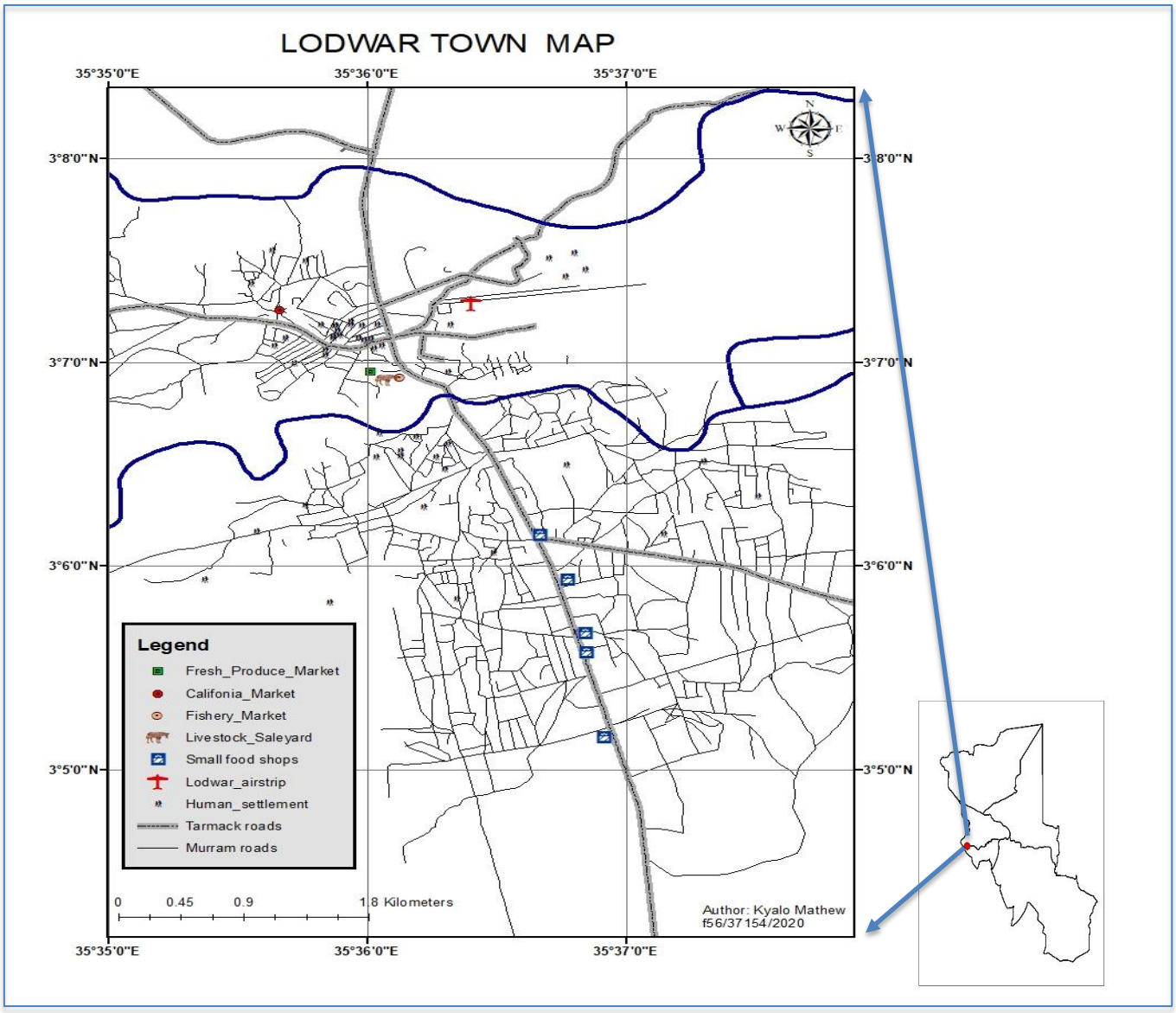


Figure 1 5 Lodwar town map with selling points

A map showing the markets, food shops, human settlements and transport routes was created, each of the markets had a photo geotagged to it so that while in the map view one was able to get additional information about the details of the market such as the name of the market, foods sold in the market, the type of the market and an image of the market by just clicking the identifier button as shown in the next page.

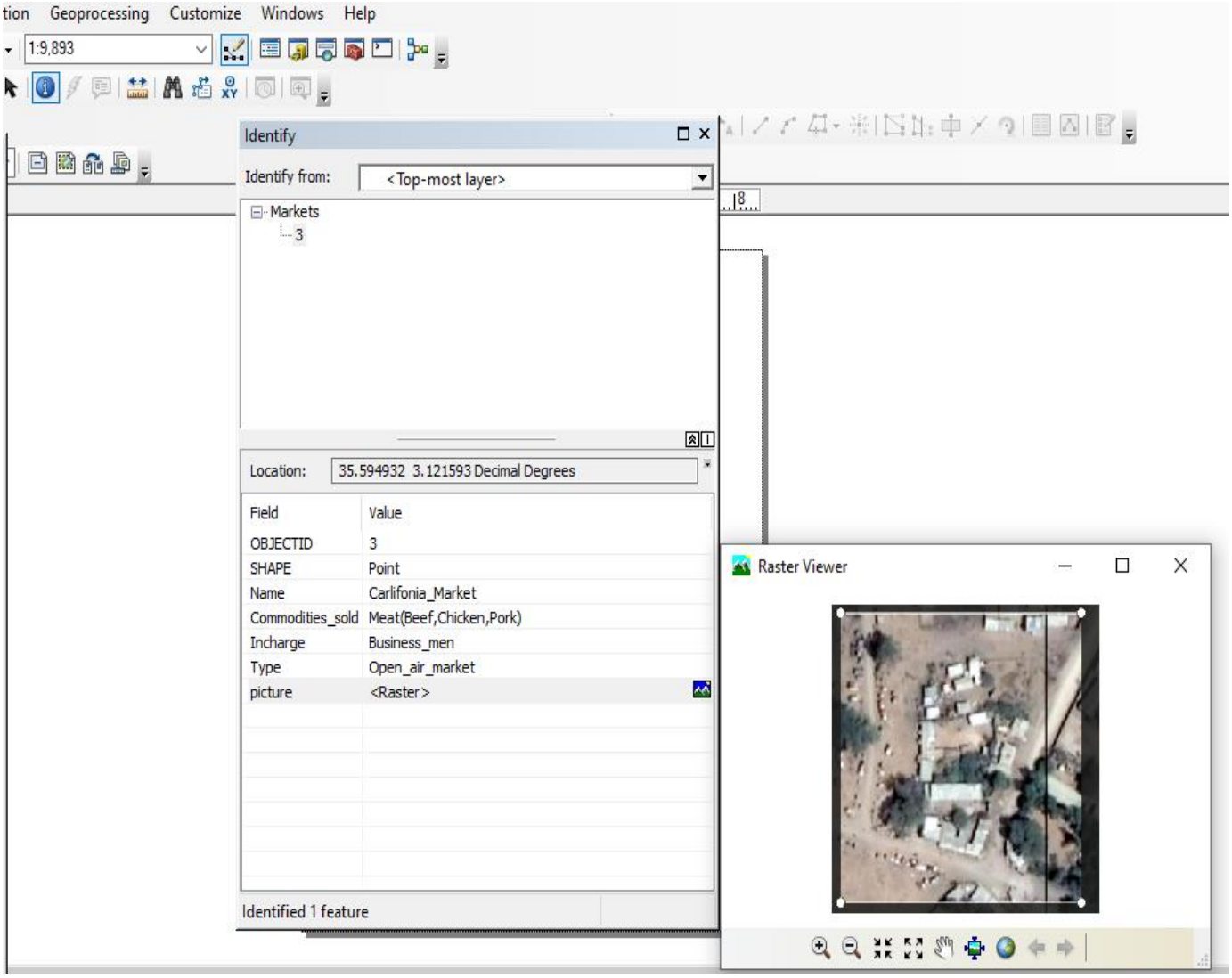


Image 1 13 Market details shown from Identifier tool

Turkana Central Irrigation schemes map

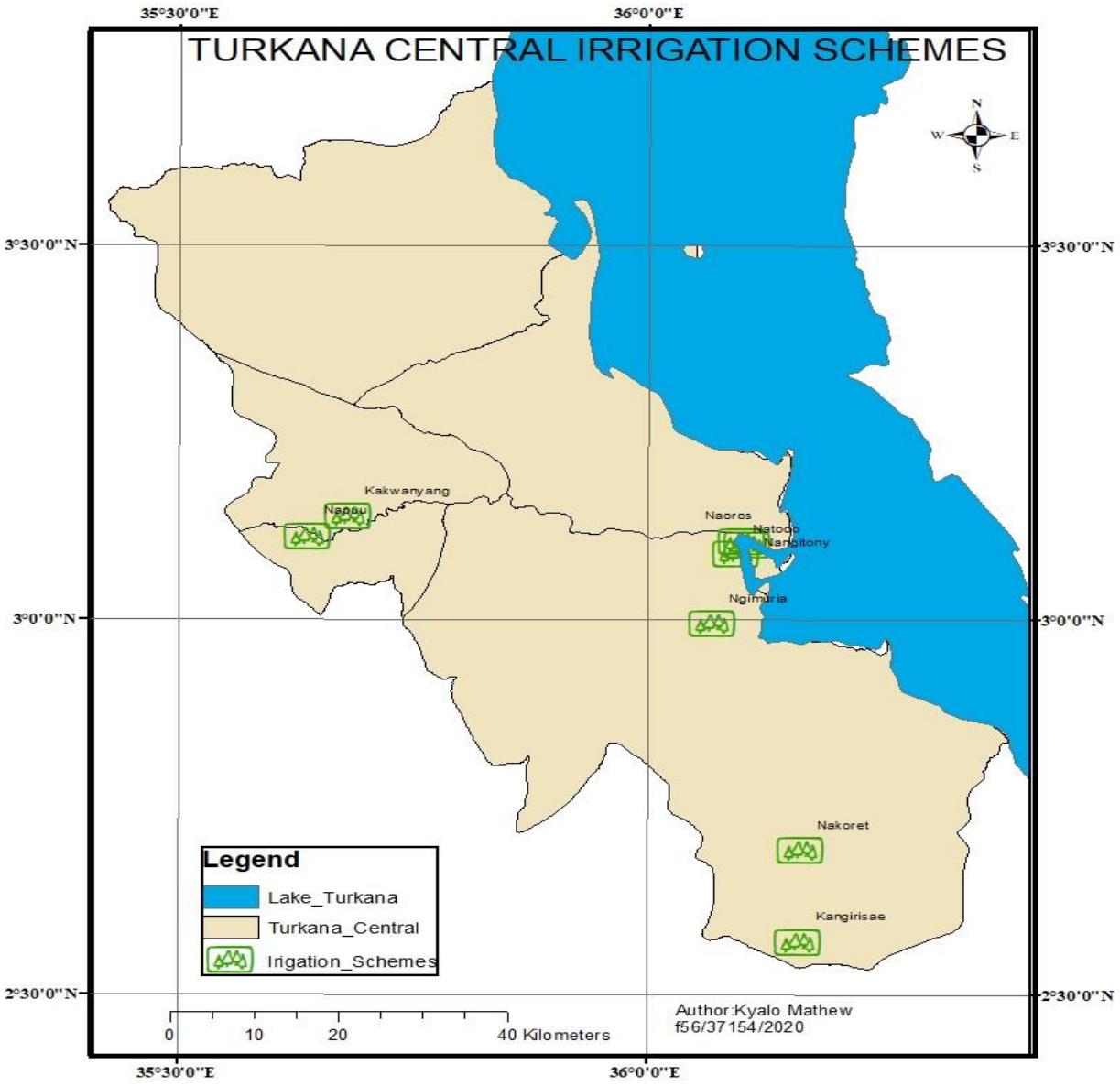


Figure 1 6 Map of irrigation schemes in Turkana Central

Turkana Central has eight major irrigation schemes, this irrigation schemes are shown in the map above, with irrigation schemes number 1 to 8 being Kangirisae, Nakoret, Ngimuria, Nadoto, Naoros, Nangitony, Kakwanyang and Napuu respectively.

Each of this irrigation schemes are unique in its own way, not only geographically but in a number of ways, and each of these schemes faces its own challenges, below is a detailed discussion of each scheme.

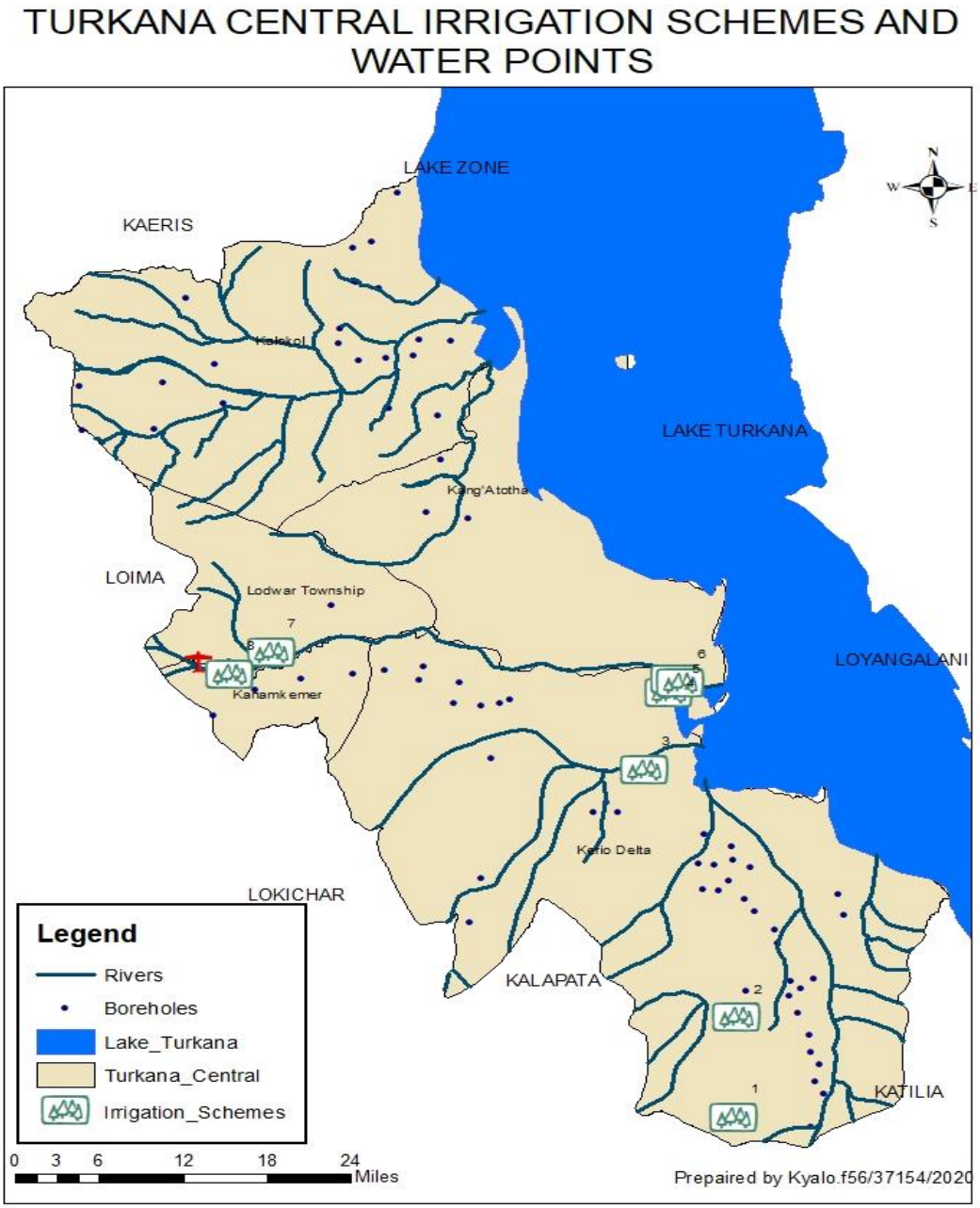


Figure 1 7 Map of water sources in relation to irrigation schemes

NOTE: In order for an area to be considered sustainable for an irrigation scheme a number of factors are considered among them, availability of water, availability of gentle or flat terrain, and favourable soils for farming. See appendices for maps of soil types and soil slopes in relation to the irrigation schemes.

4.2.1 1. Kangirisae irrigation scheme

This irrigation scheme is located in coordinates of latitude 2 degrees 33 minutes 59.22 seconds and longitude 36 degrees 9 minutes 40.96 seconds. It is located in Kerio delta Ward and is used to feed 400 households. The area under irrigation in this scheme is 30 acres whereas it has a potential of being farmed in 2,000 acres of land.

The type of irrigation farming practiced in Kangirisae is furrow irrigation and the types of crops grown here are sorghum and cowpeas.

This scheme hosts 100 farmers.

Image 1 14 Aerial image of Kangirisae irrigation Scheme

Farmers to household ratio in terms of percentage

= [**(No. of farmers / No. of households) ×100**]

= [(100 / 400) ×100]

=25%

Out of the total population in Kangirisae, 75 % of households depends on the 25% who are farmers for food.

Name of irrigation scheme	ward	Area under irrigation(Acres)	Irrigation potential (Acres)
Kangirisae	Kerio Delta	30	2000
		Utilized area(%)	Unutilized area(%)
		1.5	98.5

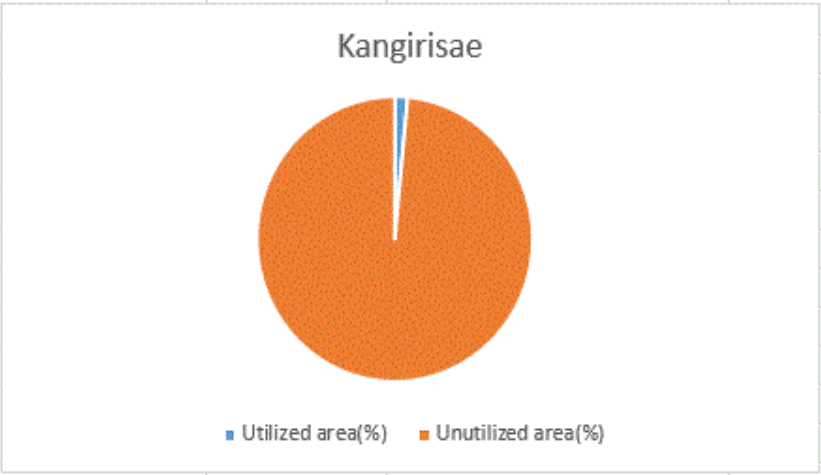


Figure 1 8 A Pie chart of Kangirisae utilized land vs unutilized irrigation land based on the potential.

Area under irrigation to Total irrigation potential ratio in terms of percentage
= [**(Area under irrigation / Total irrigation potential ratio) ×100**]
= [(30 / 2000) ×100]
=1.5%
This means that only 1.5 % of the potential land that irrigation would have been practiced is in use, and the remaining 98.5% of the potential land lies unutilized in Kangirisae Irrigation scheme.

Irrigation Scheme Name	No.of Farmers	No.of Dependants
Kangirisae	100	1600

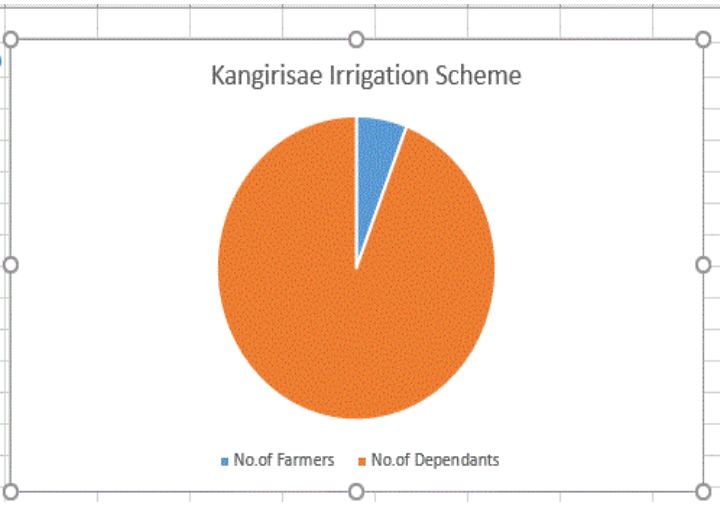
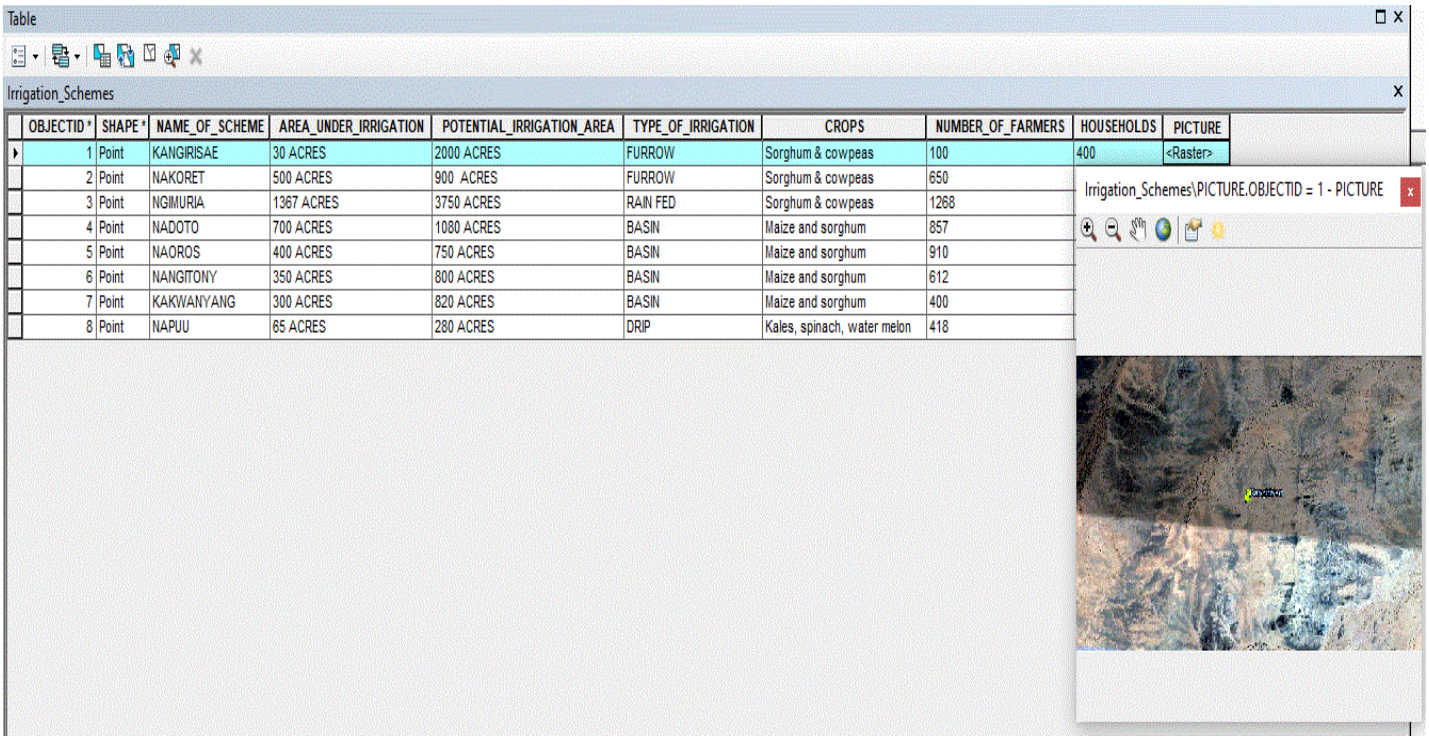


Figure 1 9 A Pie chart showing total number of farmers verses the total number of dependants

Total number of farmers to Total number of dependants in terms of percentage
= [**(Total number of farmers / Total number of dependants) ×100**]
= [(100 / 1600) ×100]
=6.25%
This means 93.75 % of people depend on the 6.25% of the farmers for food in Kangirisae.



OBJECTID *	SHAPE *	NAME_OF_SCHEME	AREA_UNDER_IRRIGATION	POTENTIAL_IRRIGATION_AREA	TYPE_OF_IRRIGATION	CROPS	NUMBER_OF_FARMERS	HOUSEHOLDS	PICTURE
1	Point	KANGIRISAE	30 ACRES	2000 ACRES	FURROW	Sorghum & cowpeas	100	400	<Raster>
2	Point	NAKORET	500 ACRES	900 ACRES	FURROW	Sorghum & cowpeas	650		
3	Point	NGIMURIA	1367 ACRES	3750 ACRES	RAIN FED	Sorghum & cowpeas	1268		
4	Point	NADOTO	700 ACRES	1080 ACRES	BASIN	Maize and sorghum	857		
5	Point	NAOROS	400 ACRES	750 ACRES	BASIN	Maize and sorghum	910		
6	Point	NANGITONY	350 ACRES	800 ACRES	BASIN	Maize and sorghum	612		
7	Point	KAKWANYANG	300 ACRES	820 ACRES	BASIN	Maize and sorghum	400		
8	Point	NAPUU	65 ACRES	280 ACRES	DRIP	Kales, spinach, water melon	418		

Image 1 15 Geotagged image of Kangirisae Irrigation Scheme

4.2.2 2. Nakoret irrigation scheme

This irrigation scheme is located in coordinates of latitude 2 degrees 41 minutes 18.76 seconds and longitude 36 degrees 9 minutes 50.84 seconds. It is located in Kerio delta Ward and is used to feed 2,600 households. The area under irrigation in this scheme is 528 acres whereas it has a potential of being farmed in 900 acres of land.

The type of irrigation farming practiced in Nakoret is furrow irrigation and the types of crops grown here are sorghum and cowpeas.

This scheme hosts 650 farmers.

Farmers to household ratio in terms of percentage

= [**(No. of farmers / No. of households) ×100**]

= [(650 / 2600) ×100]

=25%

Out of the total population in Nakoret, 75 % of households depends on the 25% who are farmers for food.

Image 1 16 Aerial image of Nakoret irrigation scheme

Name of irrigation scheme	ward	Area under irrigation(Acres)	Irrigation potential (Acres)
Nakoret	Kerio Delta	528	900
		Utilized area(%)	Unutilized area(%)
		58.66666667	41.33

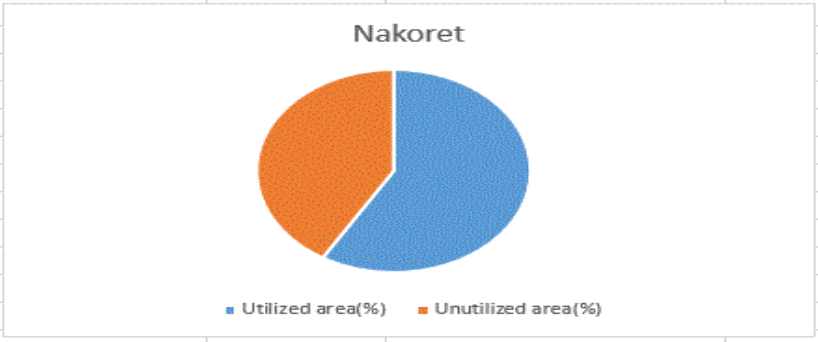


Figure 1 10 A Pie chart showing Nakoret utilized land vs unutilized irrigation land based on the potential.

Area under irrigation to Total irrigation potential ratio in terms of percentage
= [**(Area under irrigation / Total irrigation potential ratio) ×100**]
= [(528 / 900) ×100]
=58.67%
This means that only 58.67 % of the potential land that irrigation would have been practiced is in use, and the remaining 41.33% of the potential land lies unutilized in Nakoret Irrigation scheme.

Irrigation Scheme Name	No.of Farmers	No.of Dependants
Nakoret	650	10400

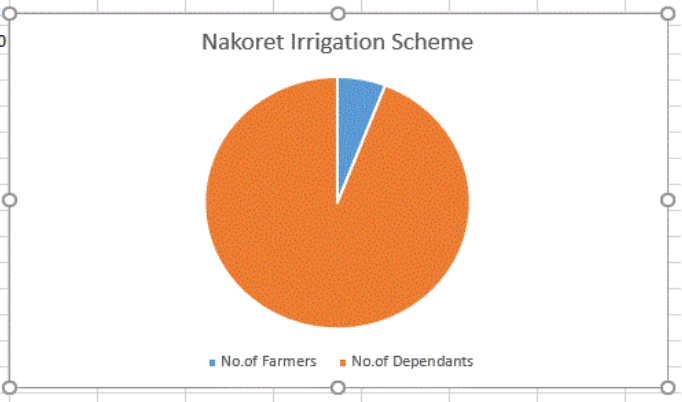
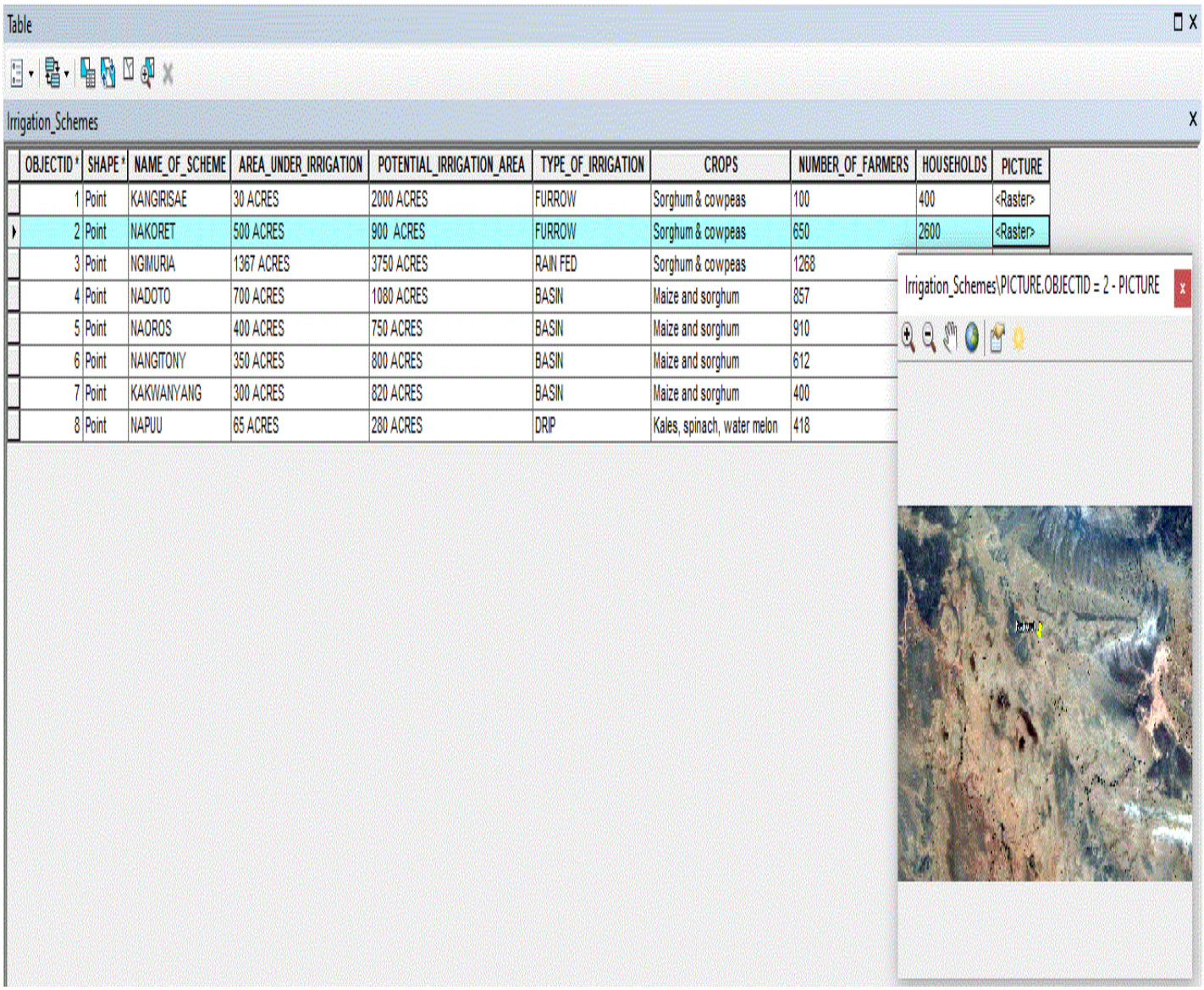


Figure 1 11 A Pie chart showing total number of farmers verses the total number of dependants

Total number of farmers to Total number of dependants in terms of percentage
= [**(Total number of farmers / Total number of dependants) ×100**]
= [(650 / 10400) ×100]
=6.25%
This means 93.75 % of people depend on the 6.25% of the farmers for food in Nakoret.



OBJECTID *	SHAPE *	NAME_OF_SCHEME	AREA_UNDER_IRRIGATION	POTENTIAL_IRRIGATION_AREA	TYPE_OF_IRRIGATION	CROPS	NUMBER_OF_FARMERS	HOUSEHOLDS	PICTURE
1	Point	KANGIRISAE	30 ACRES	2000 ACRES	FURROW	Sorghum & cowpeas	100	400	<Raster>
2	Point	NAKORET	500 ACRES	900 ACRES	FURROW	Sorghum & cowpeas	650	2600	<Raster>
3	Point	NGIMURIA	1367 ACRES	3750 ACRES	RAIN FED	Sorghum & cowpeas	1268		
4	Point	NADOTO	700 ACRES	1080 ACRES	BASIN	Maize and sorghum	857		
5	Point	NAOROS	400 ACRES	750 ACRES	BASIN	Maize and sorghum	910		
6	Point	NANGITONY	350 ACRES	800 ACRES	BASIN	Maize and sorghum	612		
7	Point	KAKWANYANG	300 ACRES	820 ACRES	BASIN	Maize and sorghum	400		
8	Point	NAPUU	65 ACRES	280 ACRES	DRIP	Kales, spinach, water melon	418		

Image 1 17 Geotagged image of Nakoret Irrigation scheme

4.2.3 3. Ngimuria irrigation scheme

This irrigation scheme is located in coordinates of latitude 2 degrees 59 minutes 27.33 seconds and longitude 36 degrees 4 minutes 5.74 seconds. It is located in Kerio delta Ward and is used to feed 2,066 households. The area under irrigation in this scheme is 1,367 acres whereas it has a potential of being farmed in 3,750 acres of land.

The type of irrigation farming practiced in Ngimuria is rainfed irrigation and the types of crops grown here are sorghum and cowpeas.

This scheme hosts 1,268 farmers.

Image 1 18 Aerial image of Ngimuria irrigation scheme

Farmers to household ratio in terms of percentage

= [**(No. of farmers / No. of households) ×100**]
= [(1268 / 2066) ×100]
=61.37%
Out of the total population in Nakoret, 38.63 % of households depends on the 61.37% who are farmers for food.

Name of irrigation scheme	ward	Area under irrigation(Acres)	Irrigation potential (Acres)
Ngimuria	Kerio Delta	1367	3750
		Utilized area(%)	Unutilized area(%)
		36.45333333	63.547

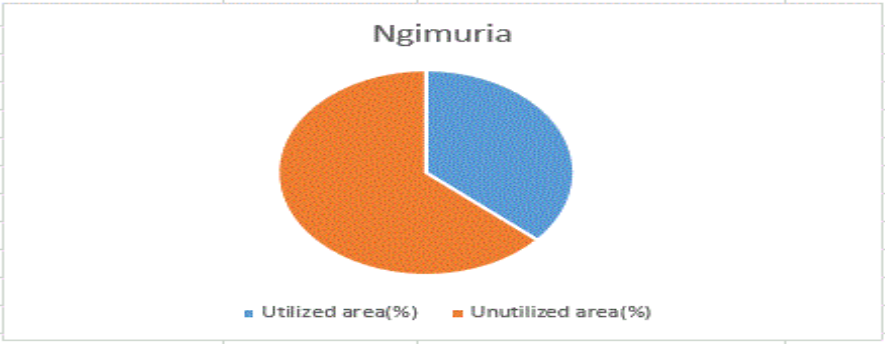


Figure 1 12 A Pie chart showing Ngimuria utilized land vs unutilized irrigation land based on the potential.

Area under irrigation to Total irrigation potential ratio in terms of percentage
= [**(Area under irrigation / Total irrigation potential ratio) ×100**]
= [(1367 / 3750) ×100]
=36.453%
This means that only 36.453 % of the potential land that irrigation would have been practiced is in use, and the remaining 63.547% of the potential land lies unutilized in Ngimuria Irrigation scheme.

Irrigation Scheme Name	No.of Farmers	No.of Dependants
Ngimuria	1268	8264

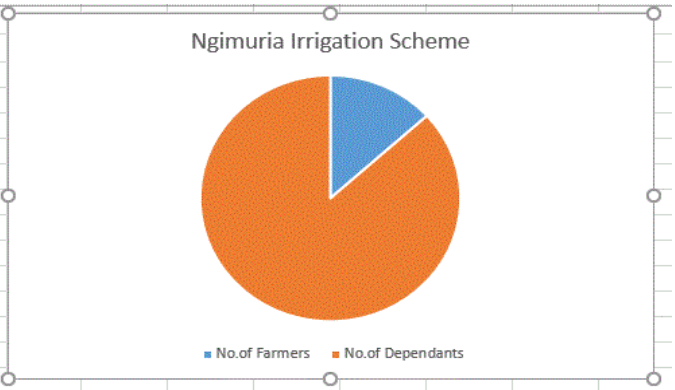
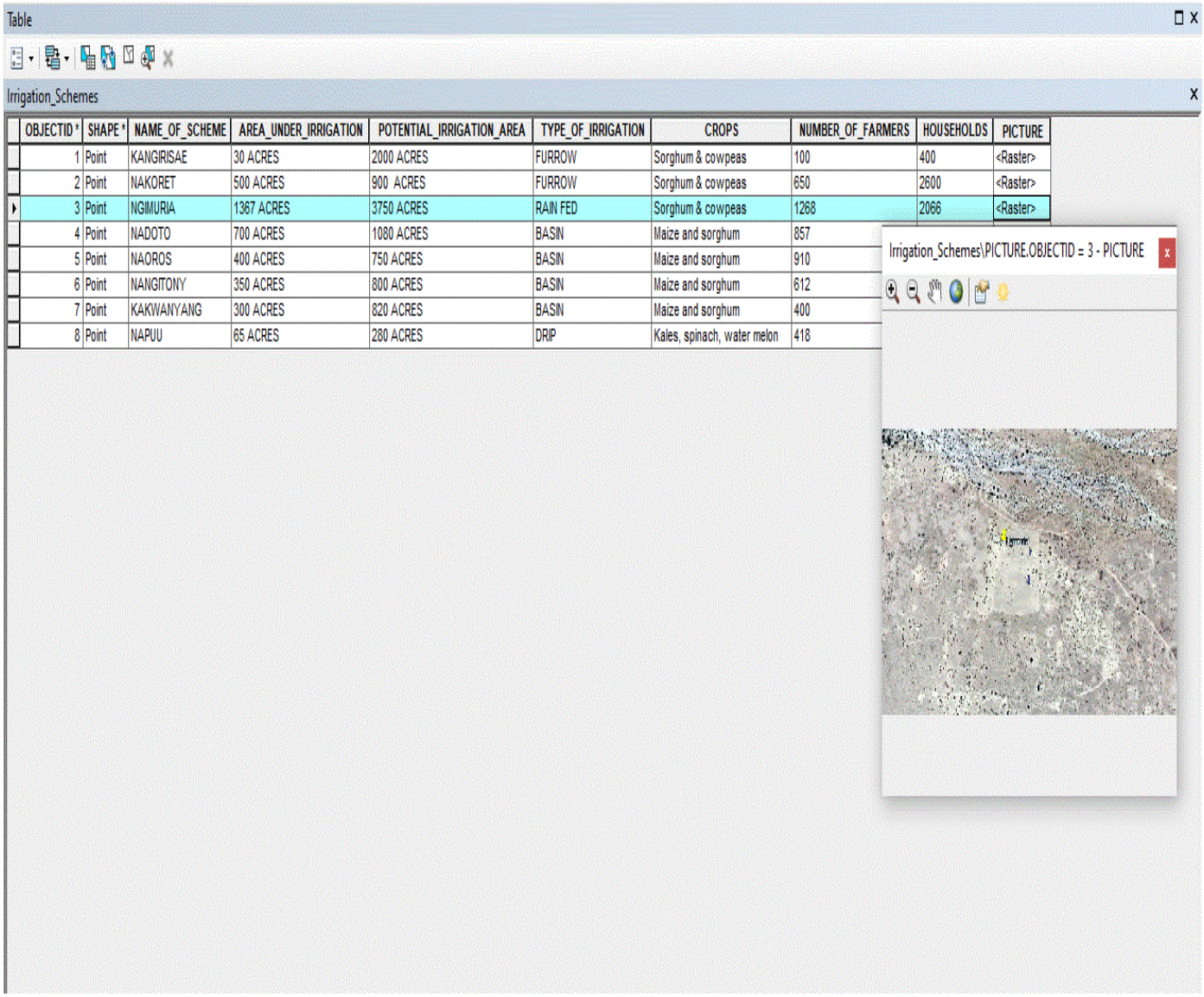


Figure 1 13 A Pie chart showing Ngimuria total number of farmers verses the total number of dependants

Total number of farmers to Total number of dependants in terms of percentage
= [(Total number of farmers / Total number of dependants) ×100]
= [(1268 / 8264) ×100]
=15.344%
This means 84.656 % of people depend on the 15.344% of the farmers for food in Ngimuria.



OBJECTID *	SHAPE *	NAME_OF_SCHEME	AREA_UNDER_IRRIGATION	POTENTIAL_IRRIGATION_AREA	TYPE_OF_IRRIGATION	CROPS	NUMBER_OF_FARMERS	HOUSEHOLDS	PICTURE
1	Point	KANGIRISAE	30 ACRES	2000 ACRES	FURROW	Sorghum & cowpeas	100	400	<Raster>
2	Point	NAKORET	500 ACRES	900 ACRES	FURROW	Sorghum & cowpeas	650	2600	<Raster>
3	Point	NGIMURIA	1367 ACRES	3750 ACRES	RAIN FED	Sorghum & cowpeas	1268	2066	<Raster>
4	Point	NADOTO	700 ACRES	1080 ACRES	BASIN	Maize and sorghum	857		
5	Point	NAOROS	400 ACRES	750 ACRES	BASIN	Maize and sorghum	910		
6	Point	NANGITONY	350 ACRES	800 ACRES	BASIN	Maize and sorghum	612		
7	Point	KAKWANYANG	300 ACRES	820 ACRES	BASIN	Maize and sorghum	400		
8	Point	NAPUU	65 ACRES	280 ACRES	DRIP	Kales, spinach, water melon	418		

Image 1 19 Geotagged image of Ngimuria Irrigation scheme

4.2.4 4. Nadoto irrigation scheme

This irrigation scheme is located in coordinates of latitude 3 degrees 5 minutes 3.384 seconds and longitude 36 degrees 5 minutes 39.036 seconds. It is located in Kerio delta Ward and is used to feed 3,428 households. The area under irrigation in this scheme is 700 acres whereas it has a potential of being farmed in 1,080 acres of land.

The type of irrigation farming practiced in Nadoto is basin irrigation and the types of crops grown here are maize and soghurm.

This scheme hosts 857 farmers.

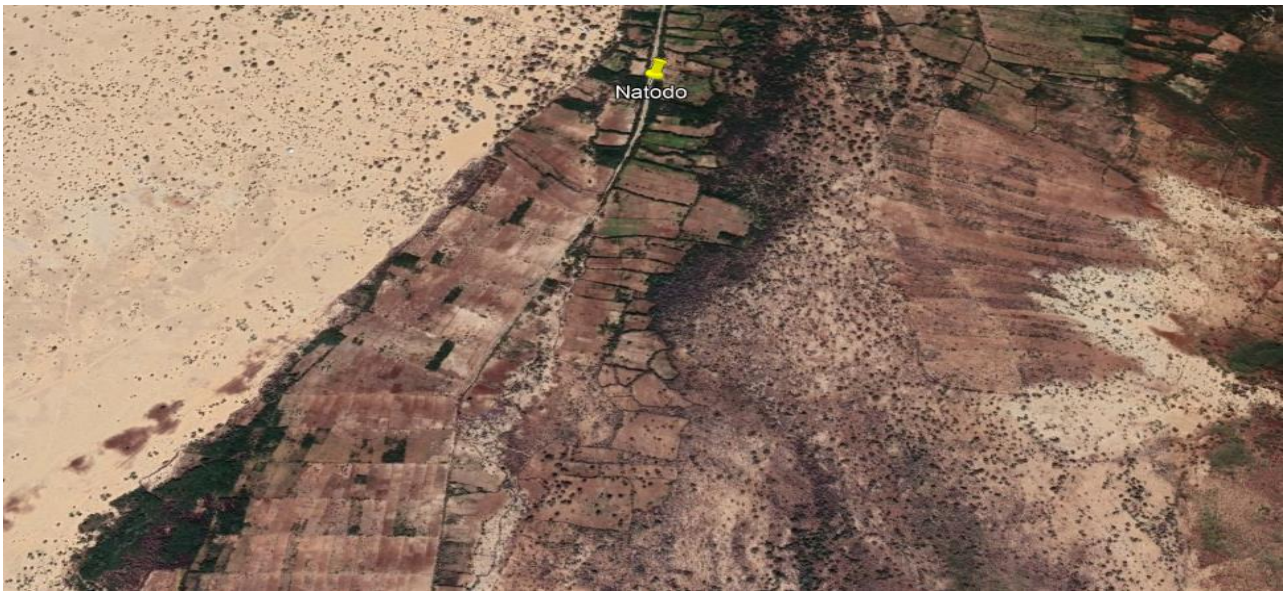


Image 1 20 Aerial image of Nadoto irrigation scheme

Farmers to household ratio in terms of percentage

= [**(No. of farmers / No. of households) ×100**]

= [(857 / 3428) ×100]

=25%

Out of the total population in Nadoto, 75 % of households depends on the 25% who are farmers for food.

Name of irrigation scheme	ward	Area under irrigation(Acres)	Irrigation potential (Acres)
Nadoto	Kerio Delta	700	1080
		Utilized area(%)	Unutilized area(%)
		64.81481481	35.18518519

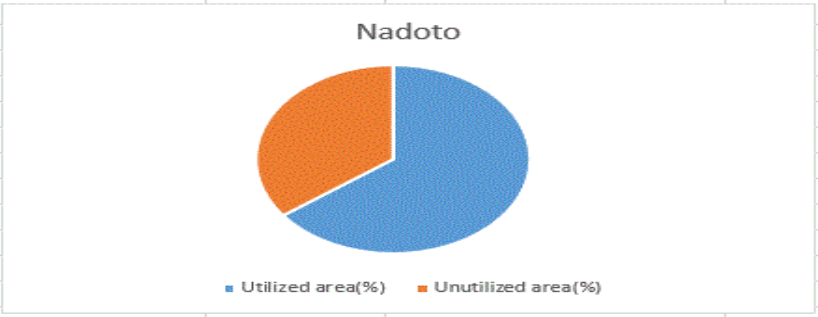


Figure 1 14 A Pie chart showing Nadoto utilized land vs unutilized irrigation land based on the potential.

Area under irrigation to Total irrigation potential ratio in terms of percentage
= [**(Area under irrigation / Total irrigation potential ratio) ×100**]
= [(700 / 1080) ×100]
=64.8148%
This means that only 64.8148 % of the potential land that irrigation would have been practiced is in use, and the remaining 35.1852% of the potential land lies unutilized in Nadoto Irrigation scheme.

Irrigation Scheme Name	No.of Farmers	No.of Dependants
Nadoto	857	13712

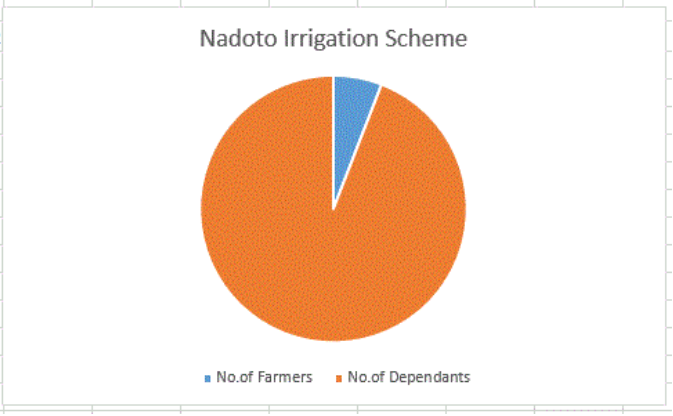


Figure 1 15 A Pie chart showing Nadoto total number of farmers verses the total number of dependants

Total number of farmers to Total number of dependants in terms of percentage
= [(Total number of farmers / Total number of dependants) ×100]
= [(857 / 13712) ×100]
=6.25%

This means 93.75 % of people depend on the 6.25% of the farmers for food in Nadoto.

Table

Irrigation_Schemes

OBJECTID *	SHAPE *	NAME_OF_SCHEME	AREA_UNDER_IRRIGATION	POTENTIAL_IRRIGATION_AREA	TYPE_OF_IRRIGATION	CROPS	NUMBER_OF_FARMERS	HOUSEHOLDS	PICTURE
1	Point	KANGIRISAE	30 ACRES	2000 ACRES	FURROW	Sorghum & cowpeas	100	400	<Raster>
2	Point	NAKORET	500 ACRES	900 ACRES	FURROW	Sorghum & cowpeas	650	2600	<Raster>
3	Point	NGIMURIA	1367 ACRES	3750 ACRES	RAIN FED	Sorghum & cowpeas	1268	2066	<Raster>
4	Point	NADOTO	700 ACRES	1080 ACRES	BASIN	Maize and sorghum	857	3428	<Raster>
5	Point	NAOROS	400 ACRES	750 ACRES	BASIN	Maize and sorghum	910		
6	Point	NANGITONY	350 ACRES	800 ACRES	BASIN	Maize and sorghum	612		
7	Point	KAKWANYANG	300 ACRES	820 ACRES	BASIN	Maize and sorghum	400		
8	Point	NAPUU	65 ACRES	280 ACRES	DRIP	Kales, spinach, water melon	418		

Irrigation_Schemes\PICTURE.OBJECTID = 4 - PICTURE

Image 1 21 Geotagged image of Nadoto Irrigation scheme

4.2.5 5. Naoros irrigation scheme

This irrigation scheme is located in coordinates of latitude 3 degrees 6 minutes 4.332 seconds and longitude 36 degrees 6 minutes 1.464 seconds. It is located in Kangatotha Ward and is used to feed 2,693 households. The area under irrigation in this scheme is 400 acres whereas it has a potential of being farmed in 750 acres of land.

The type of irrigation farming practiced in Nadoto is basin irrigation and the types of crops grown here are maize and soghurm.

This scheme hosts 910 farmers.

Image 1 22 Aerial image of Naoros irrigation scheme

Farmers to household ratio in terms of percentage

= [**(No. of farmers / No. of households) ×100**]

= [(910 / 2693) ×100]

=33.79%

Out of the total population in Nadoto, 66.21 % of households depends on the 33.79% who are farmers for food.

Name of irrigation scheme	ward	Area under irrigation(Acres)	Irrigation potential (Acres)
Naoros	Kangatotha	400	750
		Utilized area(%)	Unutilized area(%)
		53.33333333	46.67

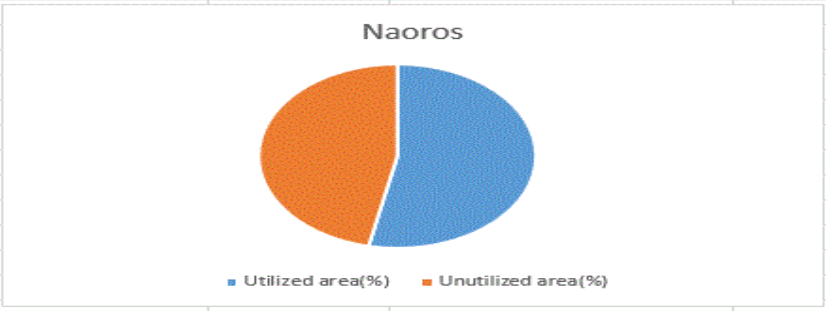


Figure 1 16 A Pie chart showing Naoros utilized land vs unutilized irrigation land based on the potential.

Area under irrigation to Total irrigation potential ratio in terms of percentage
= [**(Area under irrigation / Total irrigation potential ratio) ×100**]
= [(400 / 750) ×100]
=53.33%
This means that only 53.33 % of the potential land that irrigation would have been practiced is in use, and the remaining 46.67% of the potential land lies unutilized in Naoros Irrigation scheme.

Irrigation Scheme Name	No.of Farmers	No.of Dependants
Naoros	910	10772

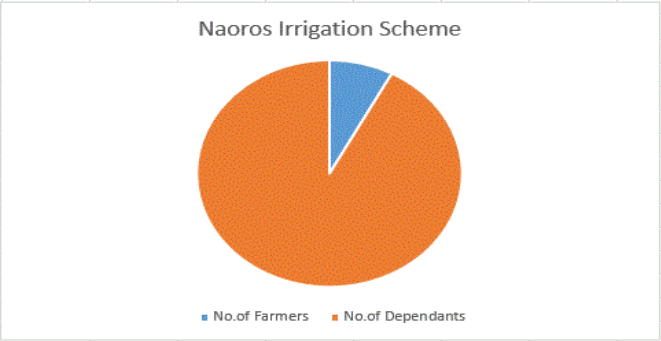


Figure 1 17 A Pie chart showing Naoros total number of farmers verses the total number of dependants

Total number of farmers to Total number of dependants in terms of percentage
= [(Total number of farmers / Total number of dependants) ×100]

= [(910 / 10772) ×100]

=8.45%

This means 91.55 % of people depend on the 8.45% of the farmers for food in Naoros.

Table

Irrigation_Schemes

OBJECTID *	SHAPE *	NAME_OF_SCHEME	AREA_UNDER_IRRIGATION	POTENTIAL_IRRIGATION_AREA	TYPE_OF_IRRIGATION	CROPS	NUMBER_OF_FARMERS	HOUSEHOLDS	PICTURE
1	Point	KANGIRISAE	30 ACRES	2000 ACRES	FURROW	Sorghum & cowpeas	100	400	<Raster>
2	Point	NAKORET	500 ACRES	900 ACRES	FURROW	Sorghum & cowpeas	650	2600	<Raster>
3	Point	NGIMURIA	1367 ACRES	3750 ACRES	RAIN FED	Sorghum & cowpeas	1268	2066	<Raster>
4	Point	NADOTO	700 ACRES	1080 ACRES	BASIN	Maize and sorghum	857	3428	<Raster>
5	Point	NAOROS	400 ACRES	750 ACRES	BASIN	Maize and sorghum	910	2693	<Raster>
6	Point	NANGITONY	350 ACRES	800 ACRES	BASIN	Maize and sorghum	612		
7	Point	KAKWANYANG	300 ACRES	820 ACRES	BASIN	Maize and sorghum	400		
8	Point	NAPUU	65 ACRES	280 ACRES	DRIP	Kales, spinach, water melon	418		

Irrigation_Schemes\PICTURE.OBJECTID = 5 - PICTURE

Image 1 23 Geotagged image of Naoros Irrigation scheme

4.2.6 6. Nangitony irrigation scheme

This irrigation scheme is located in coordinates of latitude 3 degrees 5 minutes 50.304 seconds and longitude 36 degrees 6 minutes 21.798 seconds. It is located in Kerio delta Ward and is used to feed 1,847 households. The area under irrigation in this scheme is 350 acres whereas it has a potential of being farmed in 800 acres of land.

The type of irrigation farming practiced in Nangitony is basin irrigation and the types of crops grown here are maize and sorghum.

This scheme hosts 612 farmers.

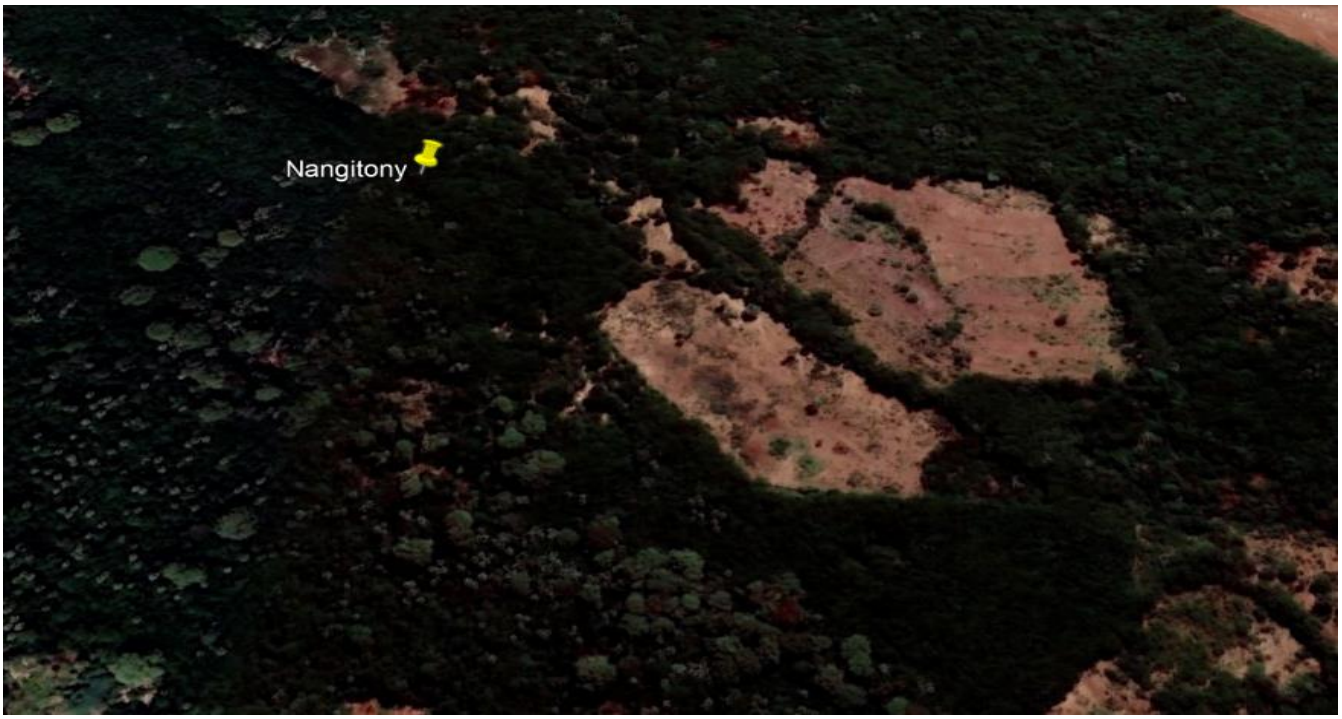


Image 1 24 Aerial image of Nangitony irrigation scheme

Farmers to household ratio in terms of percentage

= [**(No. of farmers / No. of households) ×100**]

= [(612 / 1847) ×100]

=33.13%

Out of the total population in Nangitony, 66.86 % of households depends on the 33.13% who are farmers for food.

Name of irrigation scheme	ward	Area under irrigation(Acres)	Irrigation potential (Acres)
Nangitony	Kerio delta	350	800
		Utilized area(%)	Unutilized area(%)
		43.75	56.25

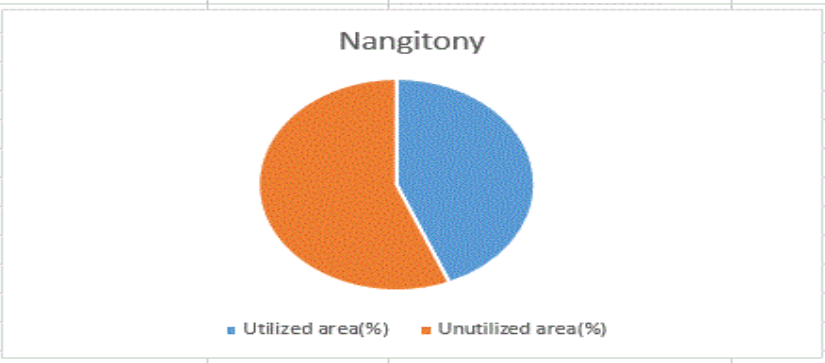


Figure 1 18 A Pie chart showing Nangitony utilized land vs unutilized irrigation land based on the potential.

Area under irrigation to Total irrigation potential ratio in terms of percentage
= [**(Area under irrigation / Total irrigation potential ratio) ×100**]
= [(350 / 800) ×100]
=43.75%
This means that only 43.75 % of the potential land that irrigation would have been practiced is in use, and the remaining 56.25% of the potential land lies unutilized in Naoros Irrigation scheme.

Irrigation Scheme Name	No.of Farmers	No.of Dependants
Nangitony	612	7388

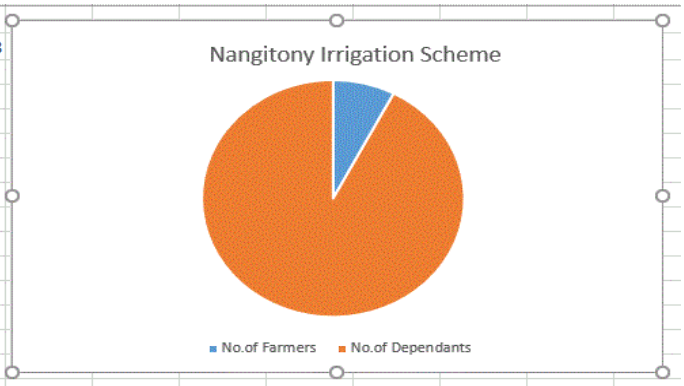


Figure 1 19 A Pie chart showing Nangitony total number of farmers verses the total number of dependants

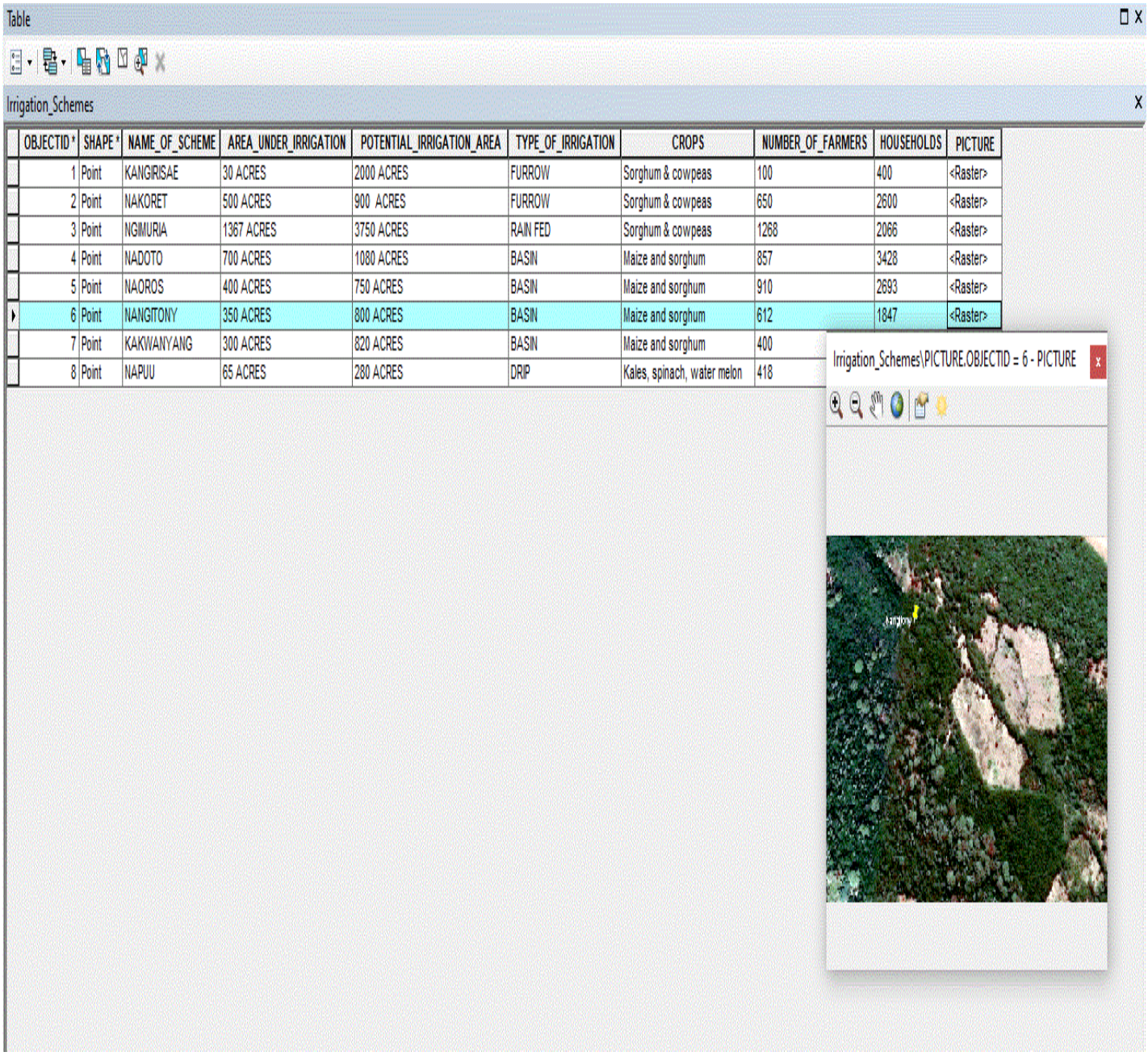
Total number of farmers to Total number of dependants in terms of percentage

= [(Total number of farmers / Total number of dependants) ×100]

= [(612 / 7388) ×100]

=8.28%

This means 91.72 % of people depend on the 8.28% of the farmers for food in Nangitony.



OBJECTID *	SHAPE *	NAME_OF_SCHEME	AREA_UNDER_IRRIGATION	POTENTIAL_IRRIGATION_AREA	TYPE_OF_IRRIGATION	CROPS	NUMBER_OF_FARMERS	HOUSEHOLDS	PICTURE
1	Point	KANGIRISAE	30 ACRES	2000 ACRES	FURROW	Sorghum & cowpeas	100	400	<Raster>
2	Point	NAKORET	500 ACRES	900 ACRES	FURROW	Sorghum & cowpeas	650	2600	<Raster>
3	Point	NGIMURIA	1367 ACRES	3750 ACRES	RAIN FED	Sorghum & cowpeas	1268	2066	<Raster>
4	Point	NADOTO	700 ACRES	1080 ACRES	BASIN	Maize and sorghum	857	3428	<Raster>
5	Point	NAOROS	400 ACRES	750 ACRES	BASIN	Maize and sorghum	910	2693	<Raster>
6	Point	NANGITONY	350 ACRES	800 ACRES	BASIN	Maize and sorghum	612	1847	<Raster>
7	Point	KAKWANYANG	300 ACRES	820 ACRES	BASIN	Maize and sorghum	400		
8	Point	NAPUU	65 ACRES	280 ACRES	DRIP	Kales, spinach, water melon	418		

Image 1 25 Geotagged image of Nangitony Irrigation scheme

4.2.7 7. Kakwanyang irrigation scheme

This irrigation scheme is located in coordinates of latitude 3 degrees 8 minutes 2.916 seconds and longitude 35 degrees 40 minutes 50.922 seconds. It is located in Lodwar Township Ward and is used to feed 1,024 households. The area under irrigation in this scheme is 300 acres whereas it has a potential of being farmed in 820 acres of land.

The type of irrigation farming practiced in Kakwanyang is basin irrigation and the types of crops grown here are maize and sorghum.

This scheme hosts 400 farmers.

Image 1 26 Aerial image of Kakwanyang irrigation scheme

Farmers to household ratio in terms of percentage

= [**(No. of farmers / No. of households) ×100**]

= [(400 / 1024) ×100]

=39.06%

Out of the total population in Kakwanyang, 60.94 % of households depends on the 39.06% who are farmers for food.

Name of irrigation scheme	ward	Area under irrigation(Acres)	Irrigation potential (Acres)
Kakwanyang	Township	300	820
		Utilized area(%)	Unutilized area(%)
		36.58536585	63.42

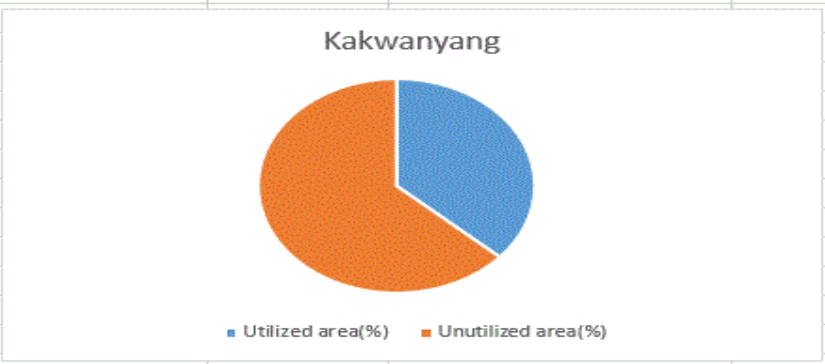


Figure 1 20 A Pie chart showing Kakwanyang utilized land vs unutilized irrigation land based on the potential.

Area under irrigation to Total irrigation potential ratio in terms of percentage
= [**(Area under irrigation / Total irrigation potential ratio) ×100**]
= [(300 / 820) ×100]
=36.59%
This means that only 36.59 % of the potential land that irrigation would have been practiced is in use, and the remaining 63.41% of the potential land lies unutilized in Kakwanyang Irrigation scheme.

Irrigation Scheme Name	No.of Farmers	No.of Dependants
Kakwanyang	400	4096

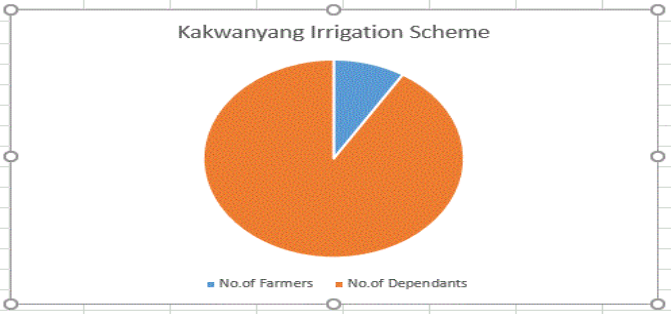


Figure 1 21 A Pie chart showing Kakwanyang total number of farmers verses the total number of dependants

Total number of farmers to Total number of dependants in terms of percentage

= [(Total number of farmers / Total number of dependants) ×100]

= [(400 / 4096) ×100]

=9.76%

This means 90.24 % of people depend on the 9.76% of the farmers for food in Kakwanyang.

Table

Irrigation_Schemes

OBJECTID *	SHAPE *	NAME_OF_SCHEME	AREA_UNDER_IRRIGATION	POTENTIAL_IRRIGATION_AREA	TYPE_OF_IRRIGATION	CROPS	NUMBER_OF_FARMERS	HOUSEHOLDS	PICTURE
1	Point	KANGIRISAE	30 ACRES	2000 ACRES	FURROW	Sorghum & cowpeas	100	400	<Raster>
2	Point	NAKORET	500 ACRES	900 ACRES	FURROW	Sorghum & cowpeas	650	2600	<Raster>
3	Point	NGIMURIA	1367 ACRES	3750 ACRES	RAIN FED	Sorghum & cowpeas	1268	2066	<Raster>
4	Point	NADOTO	700 ACRES	1080 ACRES	BASIN	Maize and sorghum	857	3428	<Raster>
5	Point	NAOROS	400 ACRES	750 ACRES	BASIN	Maize and sorghum	910	2693	<Raster>
6	Point	NANGITONY	350 ACRES	800 ACRES	BASIN	Maize and sorghum	612	1847	<Raster>
7	Point	KAKWANYANG	300 ACRES	820 ACRES	BASIN	Maize and sorghum	400	1024	<Raster>
8	Point	NAPUU	65 ACRES	280 ACRES	DRIP	Kales, spinach, water melon	418		

Irrigation_Schemes\PICTURE.OBJECTID = 7 - PICTURE

Image 1 27 Geotagged image of Kakwanyang Irrigation scheme

4.2.8 8. Napuu irrigation scheme

This irrigation scheme is located in coordinates of latitude 3 degrees 6 minutes 28.026 seconds and longitude 35 degrees 38 minutes 16.962 seconds. It is located in Kanamkemer Ward and is used to feed 1,508 households. The area under irrigation in this scheme is 65 acres whereas it has a potential of being farmed in 280 acres of land.

The type of irrigation farming practiced in Napuu is drip irrigation and the types of crops grown here are Kales, spinach and water melon. This is the only drip irrigation scheme in the county, however the county Government of Turkana is planning to develop another in Turkana Central, Napuu irrigation scheme has 209 elevated water tanks whereby 2 farmers do share 1 tank to irrigate. Each tank has a capacity of 2000 litres, these tanks are painted white to help reflect heat hence ensure they last long.

This scheme hosts 418 farmers with each farmer having a 1/4 of an acre piece of land to cultivate on.

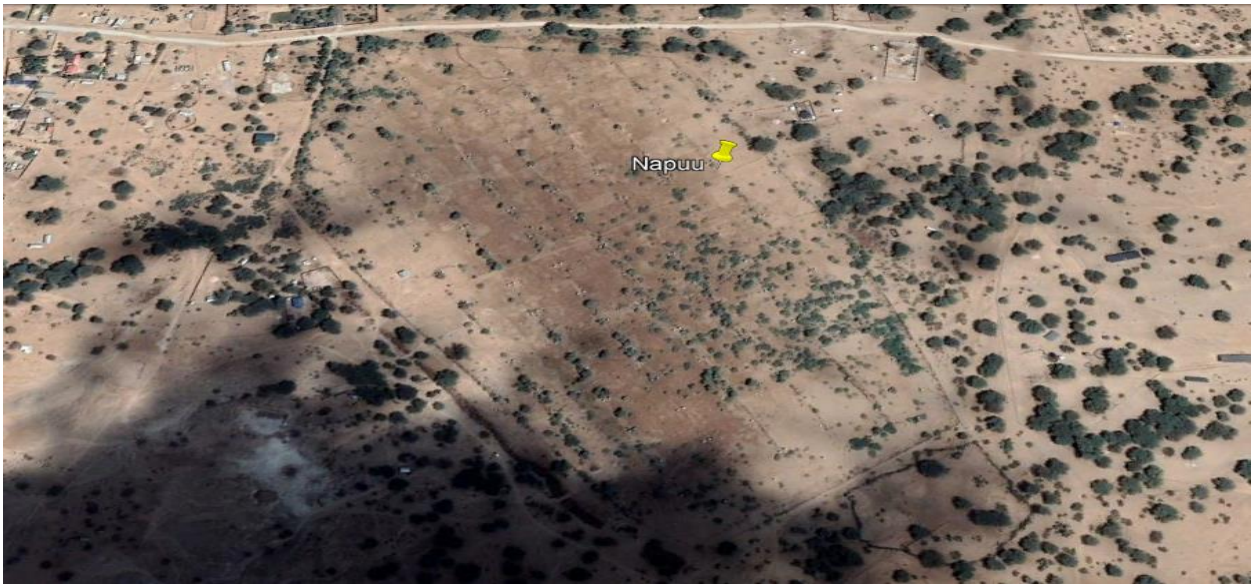


Image 1 28 Aerial image of Napuu irrigation scheme

Farmers to household ratio in terms of percentage

= [**(No. of farmers / No. of households) ×100**]

= [(418 / 1508) ×100]

=27.72%

Out of the total population in Napuu, 72.28 % of households depends on the 27.72% who are farmers for food.

Name of irrigation scheme	ward	Area under irrigation(Acres)	Irrigation potential (Acres)
Napuu	Kanamkemer	65	280
		Utilized area(%)	Unutilized area(%)
		23.21428571	76.79

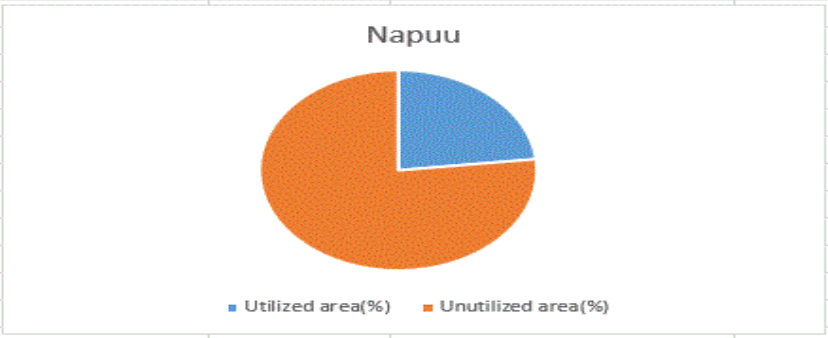


Figure 1 22 A Pie chart showing Napuu utilized land vs unutilized irrigation land based on the potential.

Area under irrigation to Total irrigation potential ratio in terms of percentage
= [**(Area under irrigation / Total irrigation potential ratio) ×100**]
= [(65 / 280) ×100]
=23.21%
This means that only 23.21 % of the potential land that irrigation would have been practiced is in use, and the remaining 76.79% of the potential land lies unutilized in Napuu.

Irrigation Scheme Name	No.of Farmers	No.of Dependants
Napuu	418	6032

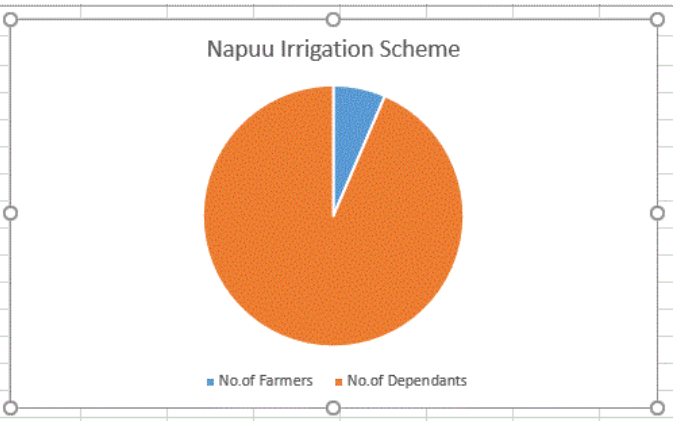


Figure 1 23 A Pie chart showing Napuu total number of farmers verses the total number of dependants

Total number of farmers to Total number of dependants in terms of percentage
= [(Total number of farmers / Total number of dependants) ×100]

= [(418 / 6032) ×100]

=6.93%

This means 93.07 % of people depend on the 6.93% of the farmers for food in Napuu.

Irrigation_Schemes

OBJECTID *	SHAPE *	NAME_OF_SCHEME	AREA_UNDER_IRRIGATION	POTENTIAL_IRRIGATION_AREA	TYPE_OF_IRRIGATION	CROPS	NUMBER_OF_FARMERS	HOUSEHOLDS	PICTURE
1	Point	KANGIRISAE	30 ACRES	2000 ACRES	FURROW	Sorghum & cowpeas	100	400	<Raster>
2	Point	NAKORET	500 ACRES	900 ACRES	FURROW	Sorghum & cowpeas	650	2600	<Raster>
3	Point	NGIMURIA	1367 ACRES	3750 ACRES	RAIN FED	Sorghum & cowpeas	1268	2066	<Raster>
4	Point	NADOTO	700 ACRES	1080 ACRES	BASIN	Maize and sorghum	857	3428	<Raster>
5	Point	NAOROS	400 ACRES	750 ACRES	BASIN	Maize and sorghum	910	2693	<Raster>
6	Point	NANGITONY	350 ACRES	800 ACRES	BASIN	Maize and sorghum	612	1847	<Raster>
7	Point	KAKWANYANG	300 ACRES	820 ACRES	BASIN	Maize and sorghum	400	1024	<Raster>
8	Point	NAPUU	65 ACRES	280 ACRES	DRIP	Kales, spinach, water melon	418	1508	<Raster>

Image 1 29 Geotagged image of Napuu Irrigation scheme

Napuu irrigation scheme being a drip type of irrigation is expected to have crops throughout the year since it does depend on artificial sources for irrigation water, however, looking at the aerial image the this is not the case, after speaking to some of the local authorities it was established that there are a few challenges that are affecting this scheme.

After the county government did survey, fencing, equipping and commissioning of this irrigation scheme the project was handed over to the community whereby a project management committee was formed, the committee was reluctant on taking over the project and as a result vandalism of the equipment emanated and theft of filters was experienced. Filters are equipment placed at the tank so that before the water gets to the drip line it is sieved off large particles that may end up blocking the pores in the pipes, it was later discovered that this filter stolen from the scheme no marly end up in local joints where it is used to sieve local brew.

About a year ago there was a pump breakdown and up to now there is nothing going on in the scheme, this is because neither the local authority nor the community wants to take responsibility, according to the local authority, the community members were trained on operation and maintenance of the scheme, and how to save some cash emanating from selling of the farm produce so that in case of a breakdown they can be able to pay a technician for repair services, but instead the committee ends up eating all the money from the proceeds.

From the details of the 8 irrigation schemes in Turkana Central,

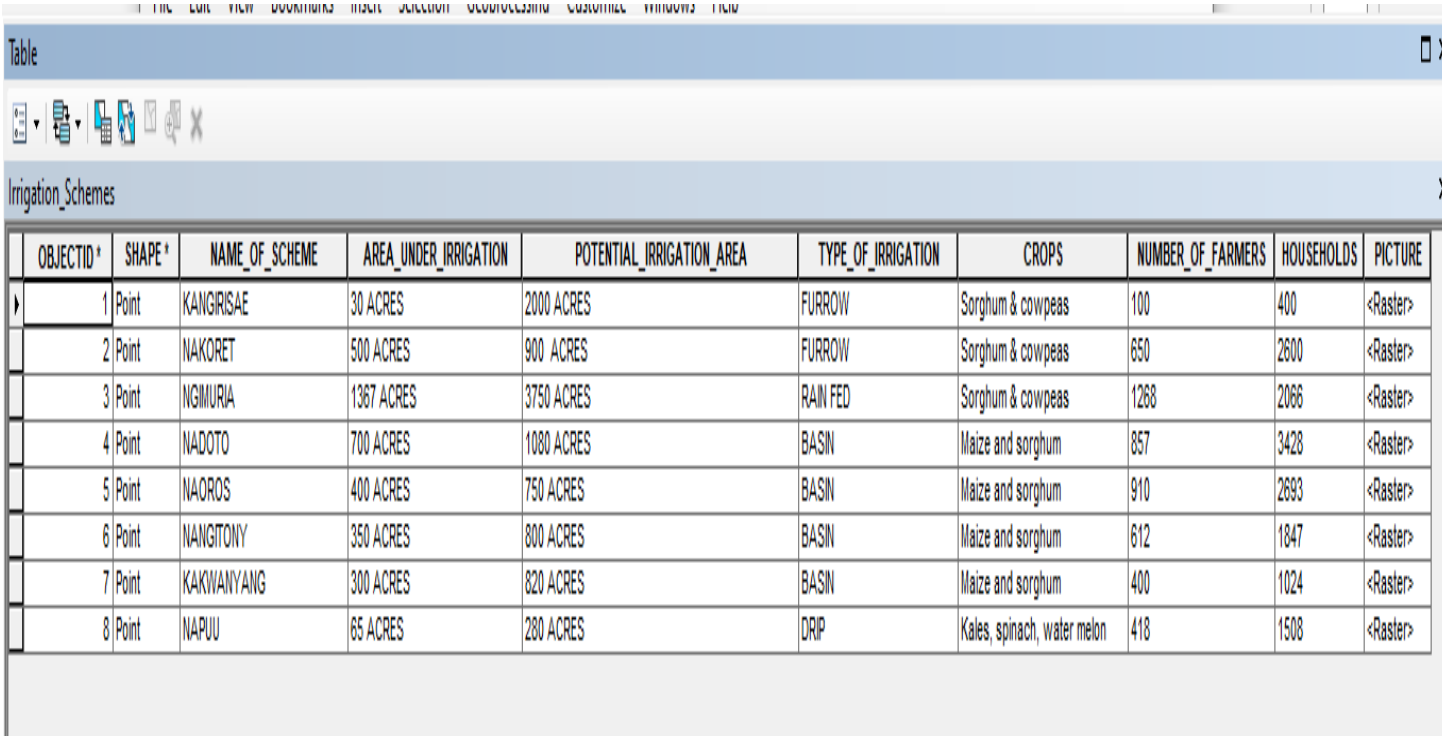
In Four (4) irrigation schemes ***basin type of irrigation*** is practiced, this are Nadoto, Nangitony and Kakwanyang schemes.

In two (2) irrigation schemes ***furrow type of irrigation*** is practiced, this are Nakoret and Kangirisae

The other two (2) irrigation schemes Ngimuria and Napuu irrigation schemes use ***Rain fed and drip irrigation methods*** respectively.

Each of the above methods differ and each has advantages and disadvantages and there is a reason as to why a specific method of irrigation is used at a specific place.

Attribute table of the Irrigation schemes



Table

Irrigation_Schemes

OBJECTID*	SHAPE*	NAME_OF_SCHEME	AREA_UNDER_IRRIGATION	POTENTIAL_IRRIGATION_AREA	TYPE_OF_IRRIGATION	CROPS	NUMBER_OF_FARMERS	HOUSEHOLDS	PICTURE
1	Point	KANGIRISAE	30 ACRES	2000 ACRES	FURROW	Sorghum & cowpeas	100	400	<Raster>
2	Point	NAKORET	500 ACRES	900 ACRES	FURROW	Sorghum & cowpeas	650	2600	<Raster>
3	Point	NGIMURIA	1367 ACRES	3750 ACRES	RAIN FED	Sorghum & cowpeas	1268	2066	<Raster>
4	Point	NADOTO	700 ACRES	1080 ACRES	BASIN	Maize and sorghum	857	3428	<Raster>
5	Point	NAOROS	400 ACRES	750 ACRES	BASIN	Maize and sorghum	910	2693	<Raster>
6	Point	NANGITONY	350 ACRES	800 ACRES	BASIN	Maize and sorghum	612	1847	<Raster>
7	Point	KAKWANYANG	300 ACRES	820 ACRES	BASIN	Maize and sorghum	400	1024	<Raster>
8	Point	NAPUU	65 ACRES	280 ACRES	DRIP	Kales, spinach, water melon	418	1508	<Raster>

Figure 1 24 Attribute table of Irrigation Schemes

According to the last census conducted in Turkana County, an average household accommodates an average of 4 people, hence to get the number of people per household we multiply by 4.

Pie Chart displaying total irrigation area verses the potential irrigation area

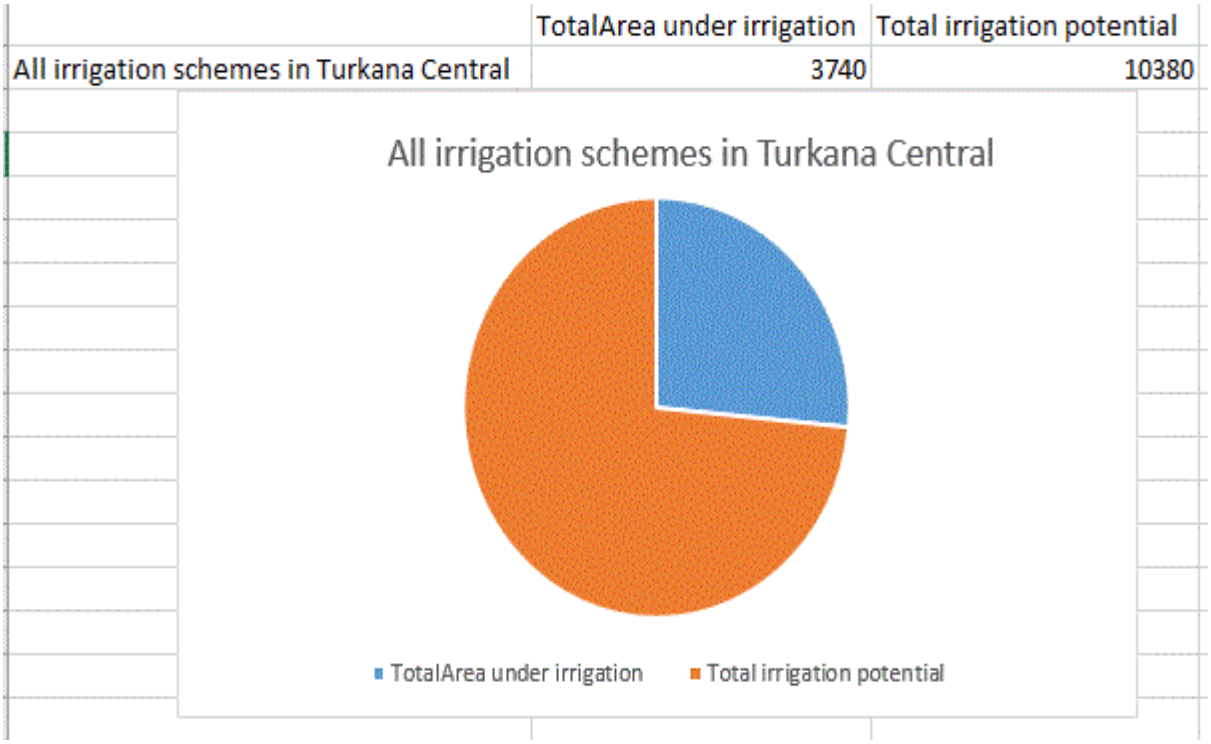


Figure 1 25 Pie chart of the cumulative area under irrigation compared to potential area that can be irrigated.

The irrigation potential of an area is gotten by determining the available area that can be converted into farm land and water availability.

4.3 Detailed Description of the types of irrigation practiced in Turkana Central

4.3.1 Basin and furrow types of Irrigation

For basin type of irrigation;

The name Basin is derived from the way irrigation water is retained or held, soil is put all around a farm at the edges and an inlet is left to allow water to flow in, when the water level has risen and the water almost overflows the entrance is closed.

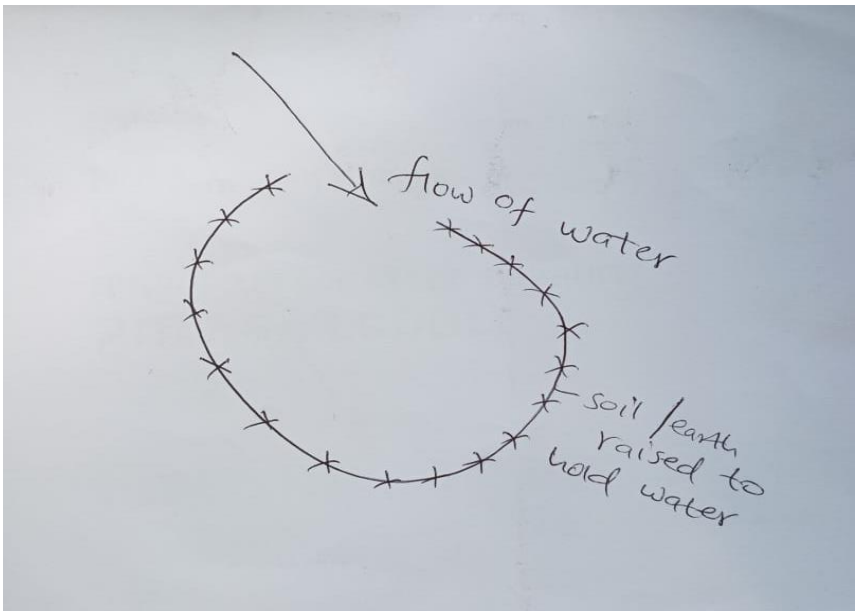


Figure 1 26 Sketch of a basin irrigation structure

Advantages of basin Irrigation

It is cheap to construct, this is because it requires less labour when compared to other types of irrigation such as furrow.

Disadvantages of basin Irrigation

There is a lot of wastage of water, this is because water is directed in an open field that is only protected at the edges to flood it.

This method encourages thriving of weeds, this is because water not only waters the crop of interest but also the places that have no crops.

For furrow type of irrigation;

The water is tapped from a river hence at the edge of a river a main canal with channels is created, the main canal should be made of concrete surface to avoid loss of water at entry point.

From the main canal are secondary canals.

The main canal can have blocks like A and B and sub main canals.

Below is an illustration

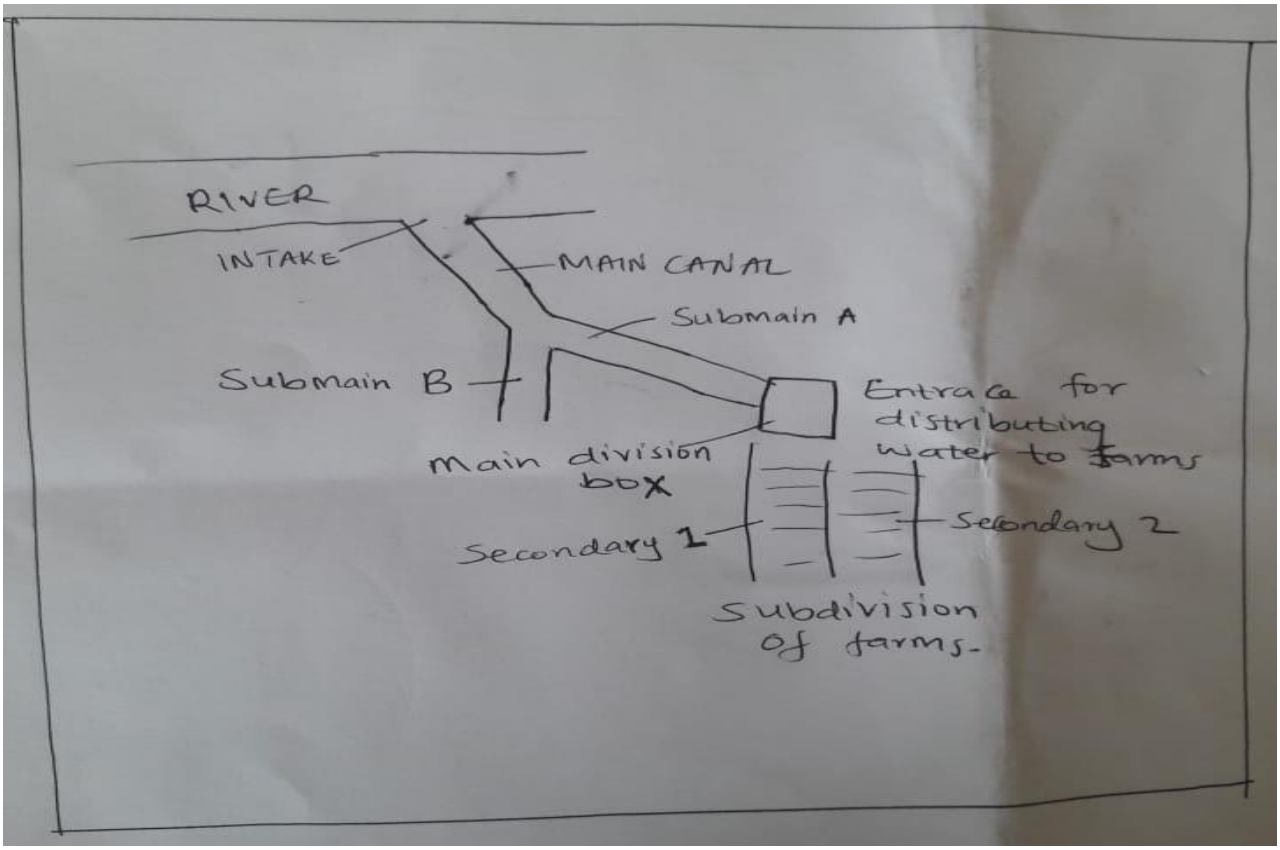


Figure 1 27 Sketch of furrow irrigation structure

Secondary 1 ,2 ,3 and so on are to distribute water to several farms within the farm.

From secondary canals we have small channels called tertiary canals leading water to different plots belonging to different farmers.

In the farm a farmer can now either use basin or furrow method to irrigate, here the whole piece of land is flooded whereby soil at the edges has earlier been lifted to say 1 foot high all round, so that when water is full in the basin the inlet is closed and the water directed to the next farmers plot.

Furrow method of irrigation has many channels created in the farm to be irrigated.

Advantages of furrow irrigation

Saves water, hence efficient use of the rare commodity especially in dry regions.

Is a great way of practicing controlled weed manifestation due to the fact that water is only directed in the furrows where planting takes place.

Disadvantages of furrow irrigation

It is labour intensive; this is because construction of the furrows requires a lot of time and energy.

It is expensive.

4.3.2 Rain fed type of Irrigation.

This type of irrigation can only be practiced during the rainy season, here a surveyor does look for a seasonal river and then diverts the route of water towards a farm.

Check dams can be used to reduce the speed of water, check dams are rocks arranged in a particular contour so as to alter the flow of water and a result reduce the speed of the water hence prevent erosion and allow the water to be used in irrigation.

Steps involved.

-Step 1-bumps made of stones are erected, when water gets to the stones it gets through the stones and this helps reduce the speed of the water.

-Step 2-Water retention ditches (channels) are made to distribute the water to different areas of the farm. When at the farm, depending on the type of the plant and depending on the topography of the slope, say if the slope is between 0-3%, soil bands are used, this are semi-circular bands.

The semi-circular shape should face the direction in which the water is flowing from so as to be able to hold water (water retention).

The other alternative of the semi-circular bands is use of Trapezoidal bands, just as the name suggests, this are trapezium shaped like bands, it has a base and two (2) wing bands.

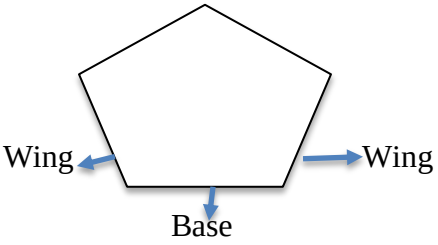


Figure 1 28 Sketch of a trapezoidal band

The trapezoidal band is set towards the water source so as to allow the wings to retain and hold water hence ensure planting inside the band. This method has been a great success in Turkana because of the relatively gentle slope, if it were in Eastern parts of Kenya where the slope is more than 20% this method would not work since the trapezoidal bands would be washed away by water due to speed of flow. In areas with steep slope the method advised is called *fanya juu fanya chini* where by assuming you are on a hill where the hill is the source of the water, a trench is made, soil from the trench is put downstream of the channel, if the soil is put upstream then it is called *fanya juu,* this helps the water to have a certain drop, and since the trench is at a zero gradient, the speed of the water will be reduced say from 5m/s to 0 m/s and hence planting can take place here.

4.3.3 Drip type of Irrigation.

There is only 1 type of this irrigation in Turkana central sub-County, however plans are underway to setup another one of this kind of scheme in Turkana Central. This type of irrigation entails pipes connected to elevated tanks, these pipes have small pores so that water oozes out of this pore and gets to the soil, the pipes with pores are laid on farms close to the plants hence water slowly seeps throughout hence ensuring the ground is moist throughout for the benefit of the crops.

4.4 Fishing Zones

Turkana Central Fishing Zones Map

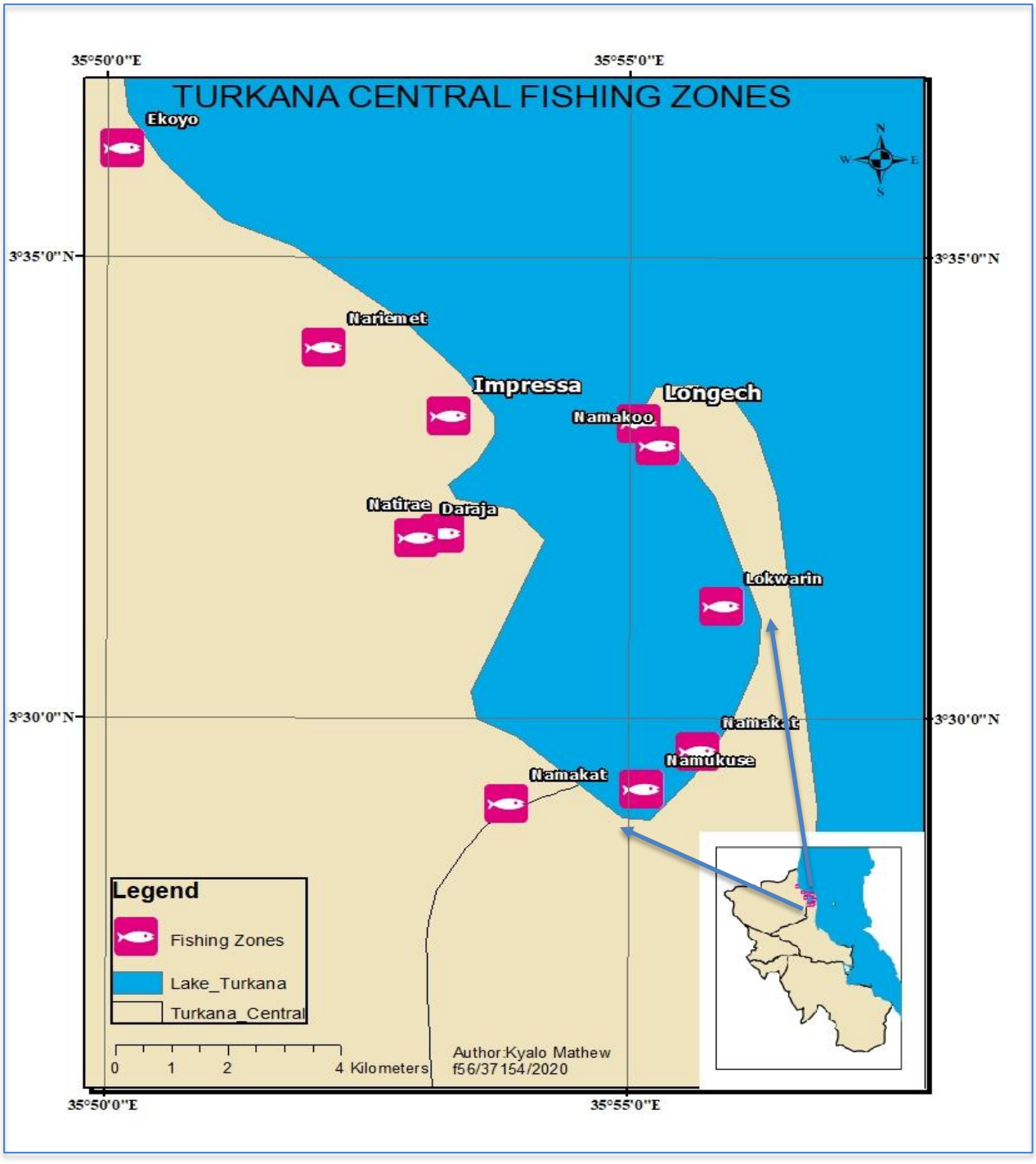


Figure 1 29 Turkana central fishing Zones map

The type of fish in Lake Turkana are Tilapia and Nile perch.

The fishing zones Attribute Table

Table

Points

OID *	Shape *	Name	FolderPath	Image
1	Point Z	Impressa	Kalokol map.kmz/Kalokol map	<Raster>
3	Point Z	Ekoyo	Kalokol map.kmz/Kalokol map	<Raster>
5	Point Z	Namakat	Kalokol map.kmz/Kalokol map	<Raster>
6	Point Z	Longech	Kalokol map.kmz/Kalokol map	<Raster>
8	Point Z	Namakoo	Kalokol map.kmz/Kalokol map	<Raster>
9	Point Z	Lokwarin	Kalokol map.kmz/Kalokol map	<Raster>
10	Point Z	Namukuse	Kalokol map.kmz/Kalokol map	<Raster>
11	Point Z	Namakat	Kalokol map.kmz/Kalokol map	<Raster>
12	Point Z	Longech	Kalokol map.kmz/Kalokol map	<Raster>
13	Point Z	Natirae	Kalokol map.kmz/Kalokol map	<Raster>
14	Point Z	Daraja	Kalokol map.kmz/Kalokol map	<Raster>
15	Point Z	Nariemet	Kalokol map.kmz/Kalokol map	<Raster>

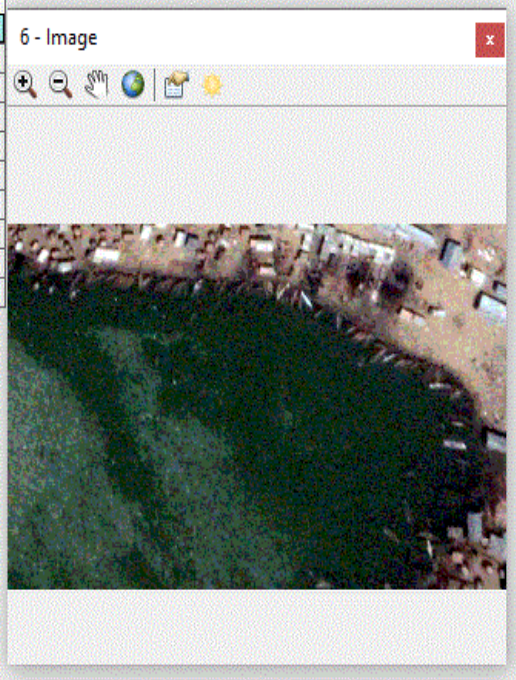


Image 1 30 Turkana central fishing Zones Attribute table

From the geotagged image, the white structures at the edge of the lake are the boats used by fishermen.

At this fishing zones fish is preserved using different methods among them, smoking, deep frying, drying and salting.

The drying stores are owned by individuals.

Fishing Lodge Images

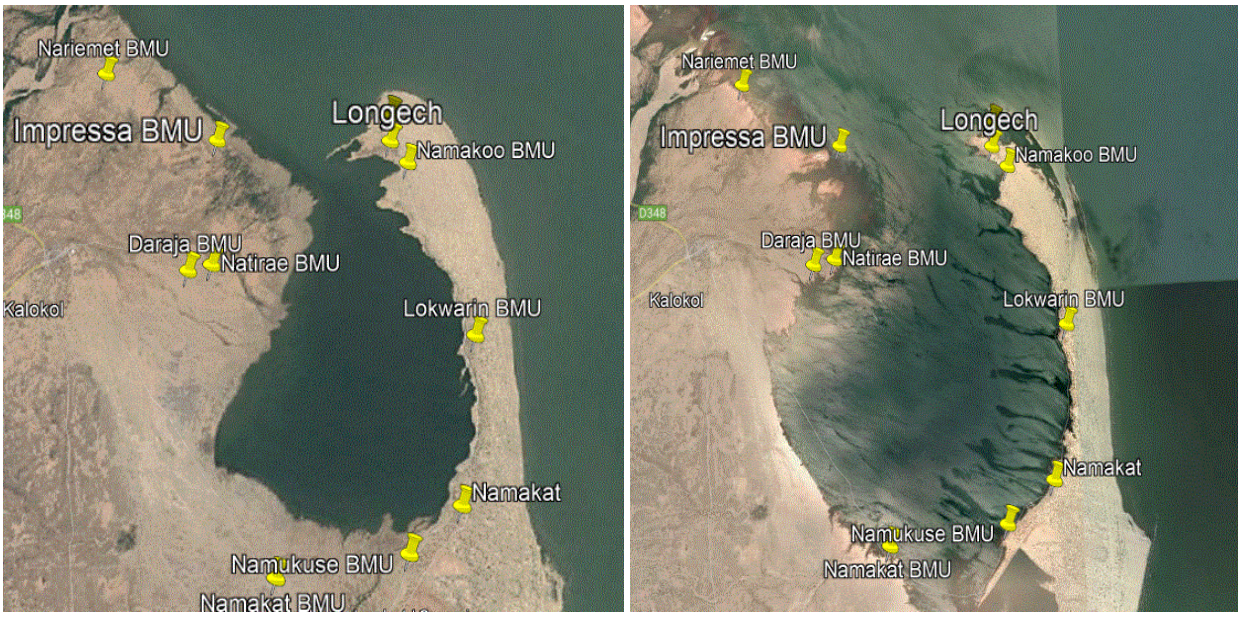


Image taken in the year 2016 vs Image taken in the year 2022

Image 1 31 Fishing Lodge

Note that the fishing lodge is decreasing in size due to the increase in water levels over the past few years, in fact some of the BMU's have already been submerged.

According to Engineer Evans who owns a cold chain facility at the shores of Lake Turkana, the rise in water levels is attributed to the shifting in Tectonic plates in the rift valley, this is the reason most rift valley lakes including Lake Baringo and Naivasha have had a rise in water levels in the recent years.

4.5 Food stores

Mega food storage facilities map

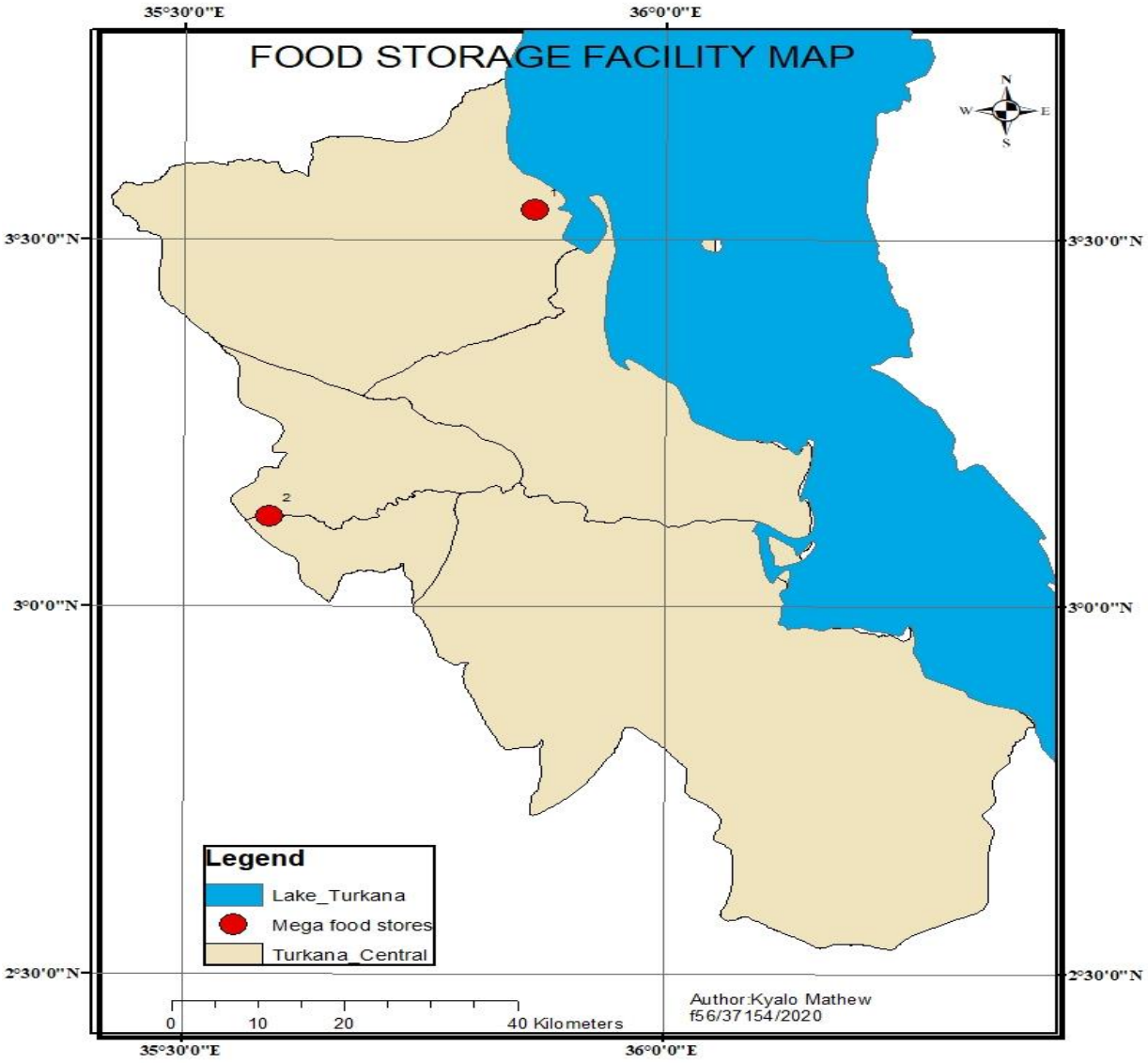


Figure 1 30 Turkana central sub county food stores map

Turkana central sub county has only two mega food stores, however there are many small shops that act like food stores but mapping them wasn't necessary as most of them aren't consistent and today they may be food stores and, in a few days, converted to a different premise.

The two food stores are at Kalokol ward a fish store and at Lodwar Township a cereals store.

Mega food storage facilities map with road network

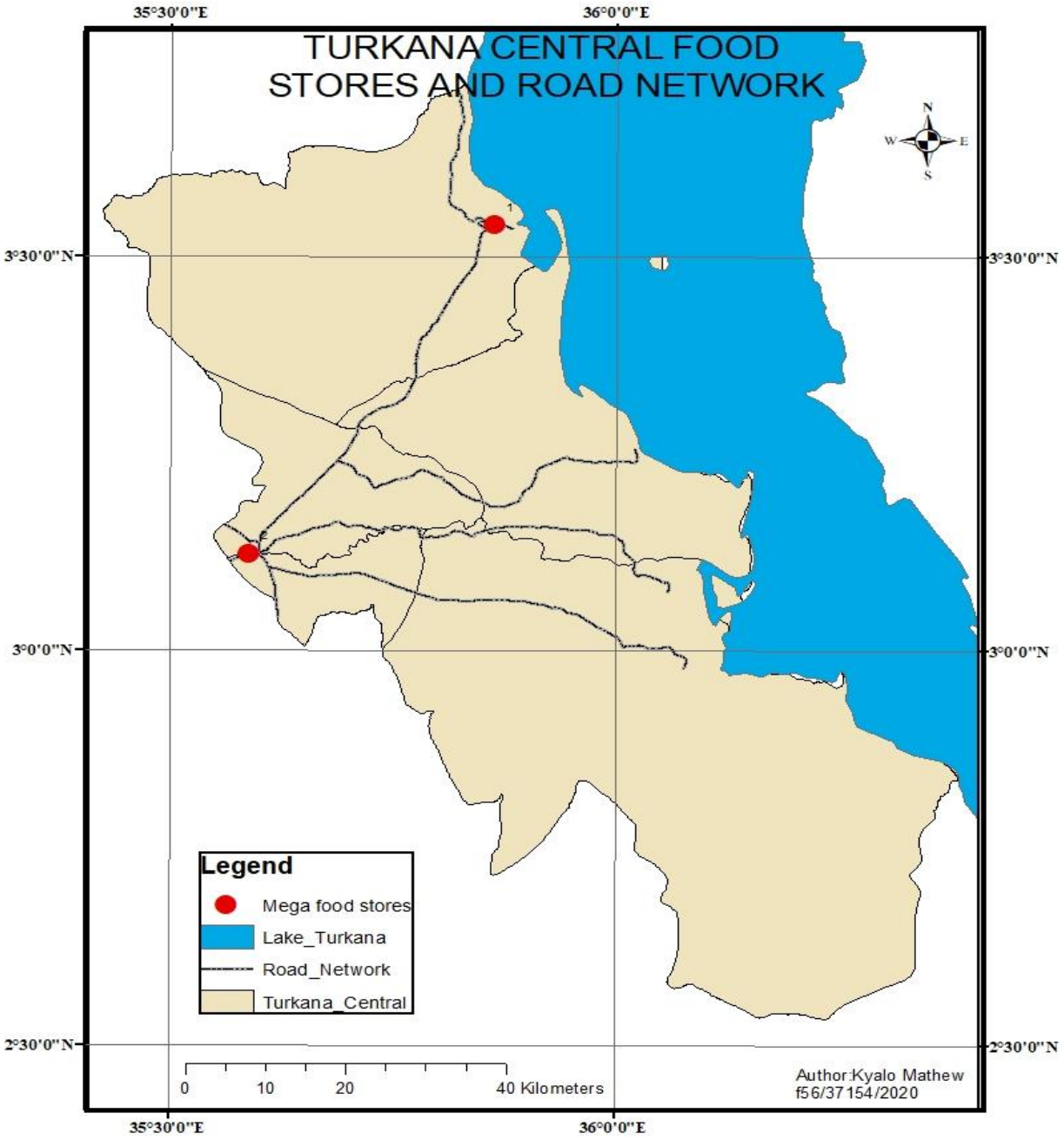
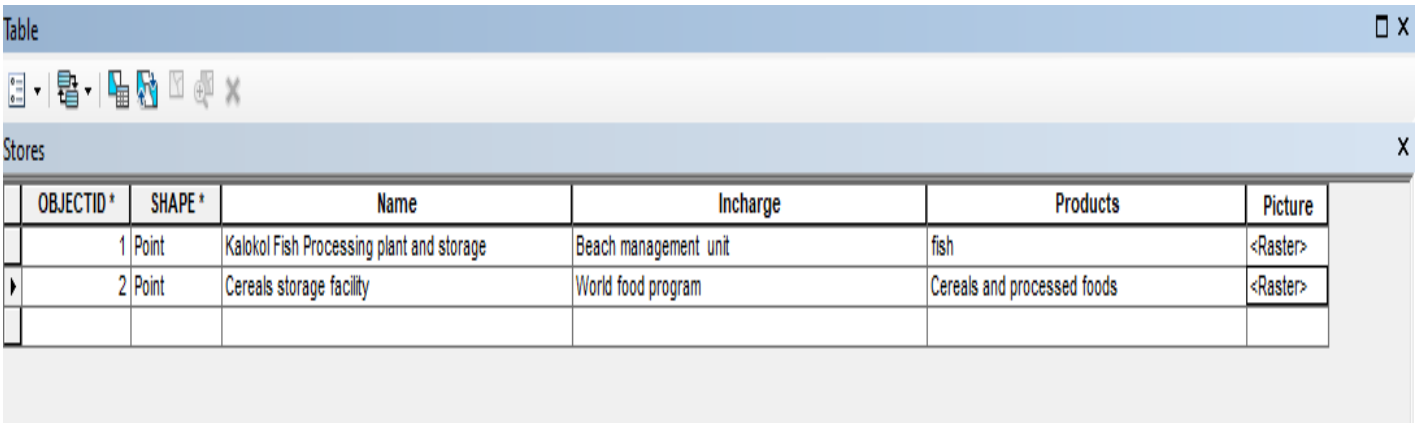


Figure 1 31 Turkana central sub county transport and food stores map



OBJECTID *	SHAPE *	Name	Incharge	Products	Picture
1	Point	Kalokol Fish Processing plant and storage	Beach management unit	fish	<Raster>
2	Point	Cereals storage facility	World food program	Cereals and processed foods	<Raster>

Figure 1 32 An attribute table of the 2 mega storage facilities attribute table

Kalokol fish processing plant and Storage

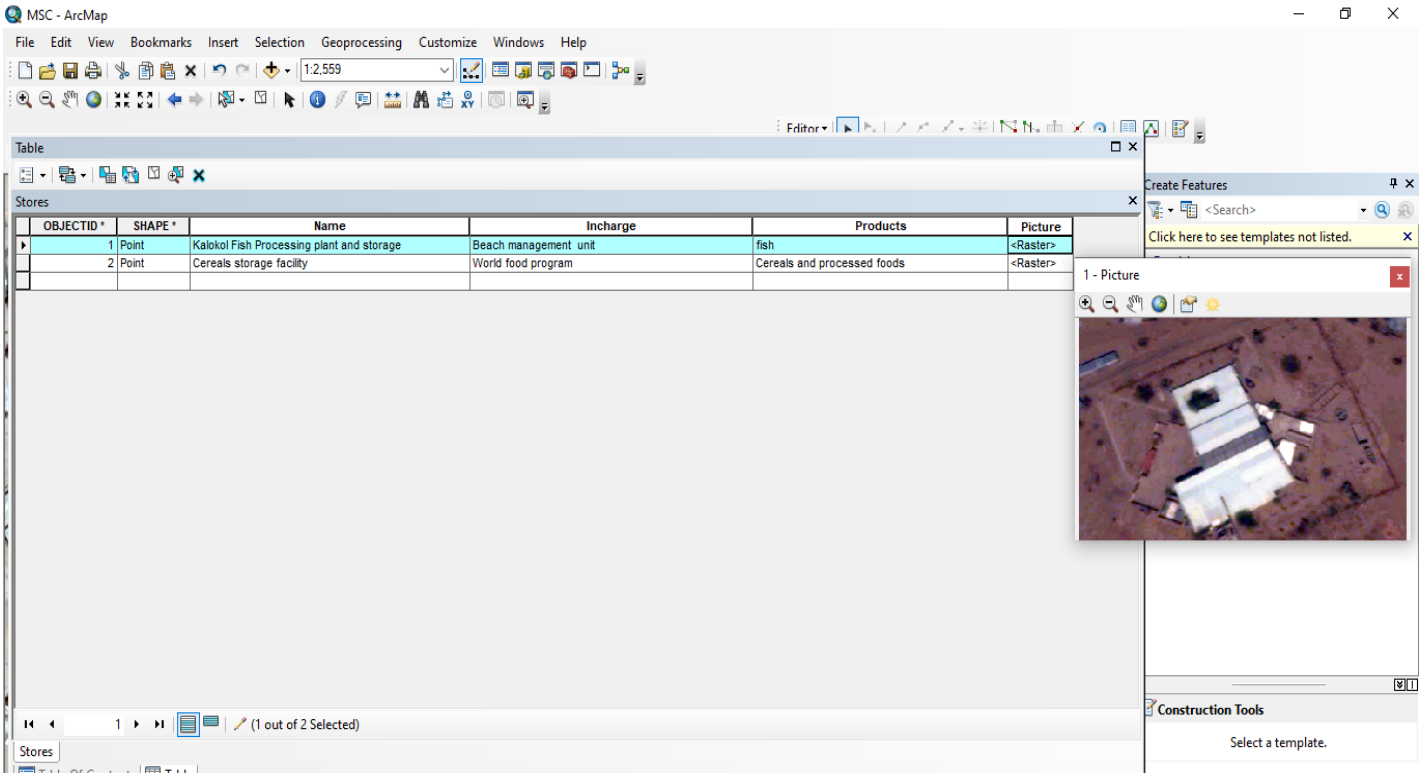


Image 1 32 A snapshot showing how the geotagged image of the Kalokol fish plant looks like.

Both the two storage facilities had their images geotagged to them, below is the pictures and details of Kalokol fish plant facility.

Image 1 33 Image of the fish processing plant in Kalokol

In Kalokol fishing and matters fish production and processing are monitored and controlled by the Beach Management Unit (BMU). The Beach management unit does control fishing at a particular beach by say registering an association of bodies where fishermen are given specific areas to fish at.

The fishermen do fish and sell their produce to BMU. It is the BMU that does process of the fish, that is removal of scales and the unwanted internal organs of the fish, then when the fish is ready it is preserved before transportation.

There are two methods of preserving this fish, deep freezing and smoking, both are practiced in this plant but smoking is the most preferred since the fish are later transported in open trucks to other countries such as Congo, most Congolese citizens have also invaded the lake to ensure they do supply enough quantity to their people back home. The deep-frozen fish are mostly transported within the country to areas such as Kitale, Eldoret and Nairobi.

A company by the name Adili solar hubs limited does the freezing of the fish collected from the Lake since they have the ice making machine, they handle 4 tons of fish per week due to their size but the fishermen do produce almost 6 tonnes per day depending on the weather, this is

according to Engineer Evans who runs the plant. The frozen fish is later on sold to business men with trucks that have deep freezers hence the fish is later on transported to Gikomba market in Nairobi City, Homabay County and Eldoret Town.

The rest of the fish that is not transported is locally consumed, most people do prefer fish from lake Turkana because of the unique taste this fish have, this is due to the fact that lake Turkana is considered a salty water lake and hence its fish have got a specific salty like taste.

The love of fish from lake Turkana can be proven by the fact that most of the fish consumed in Busia is from Turkana yet considering the proximity of Busia to Lake Victoria it would be easier to access fish from Lake Victoria.

The other reason for Lake Turkana's fish being common is due to the fact that the management of Lake Victoria imposes more restrictions on fishing here, this results to fish from Lake Victoria being more expensive due to the size restrictions.

Example, a fish retailing at 200 shillings from Lake Turkana would retail at 500 shillings if it were from Lake Victoria. And since the only competition of Fish from Lake Turkana is fish from Lake Victoria, it is easy to edge out this type of competition due to taste and prize issues.

Cereal's storage facility

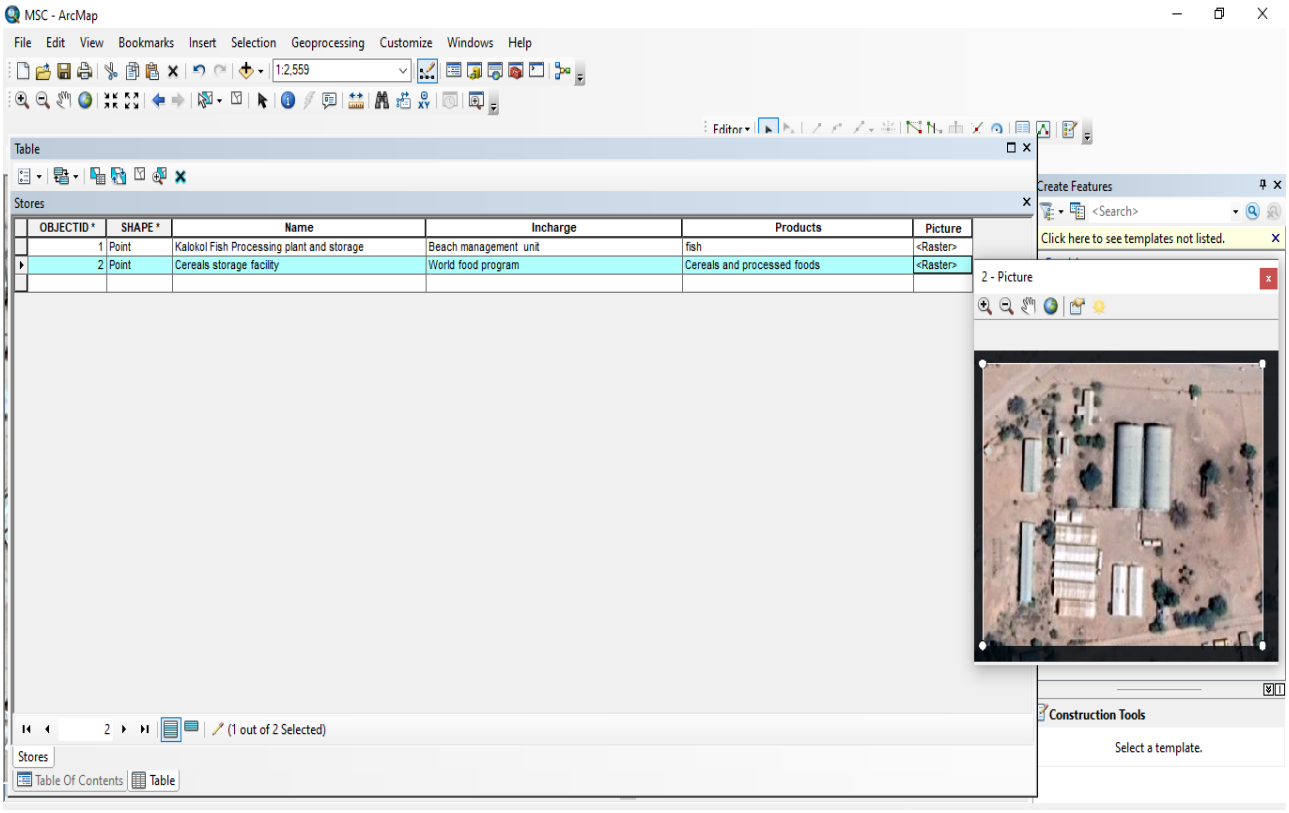


Image 1 34 A snapshot showing how the geotagged image of the Cereals storage facility looks like.

Image 1 35 Picture of the Cereals storage facility.

The storage facility is in Lodwar Township, this facility was constructed and commissioned by the World Food Program (WFP) so as to help curb food insecurity in the arid areas of Turkana area.

There are two stores as seen in the image, 1 store is used by the national government and the other store is used by the World food Organization together with the county Government of Turkana. Each of these stores has a capacity of holding 100,000 metric tons of cereals.

Currently both the two stores have no food inside them but the county government has already advertised a tender so that anyone with capabilities to supply food can apply for it.

These two stores are used as distribution points for foods to subcounty and wards throughout the whole Turkana County.

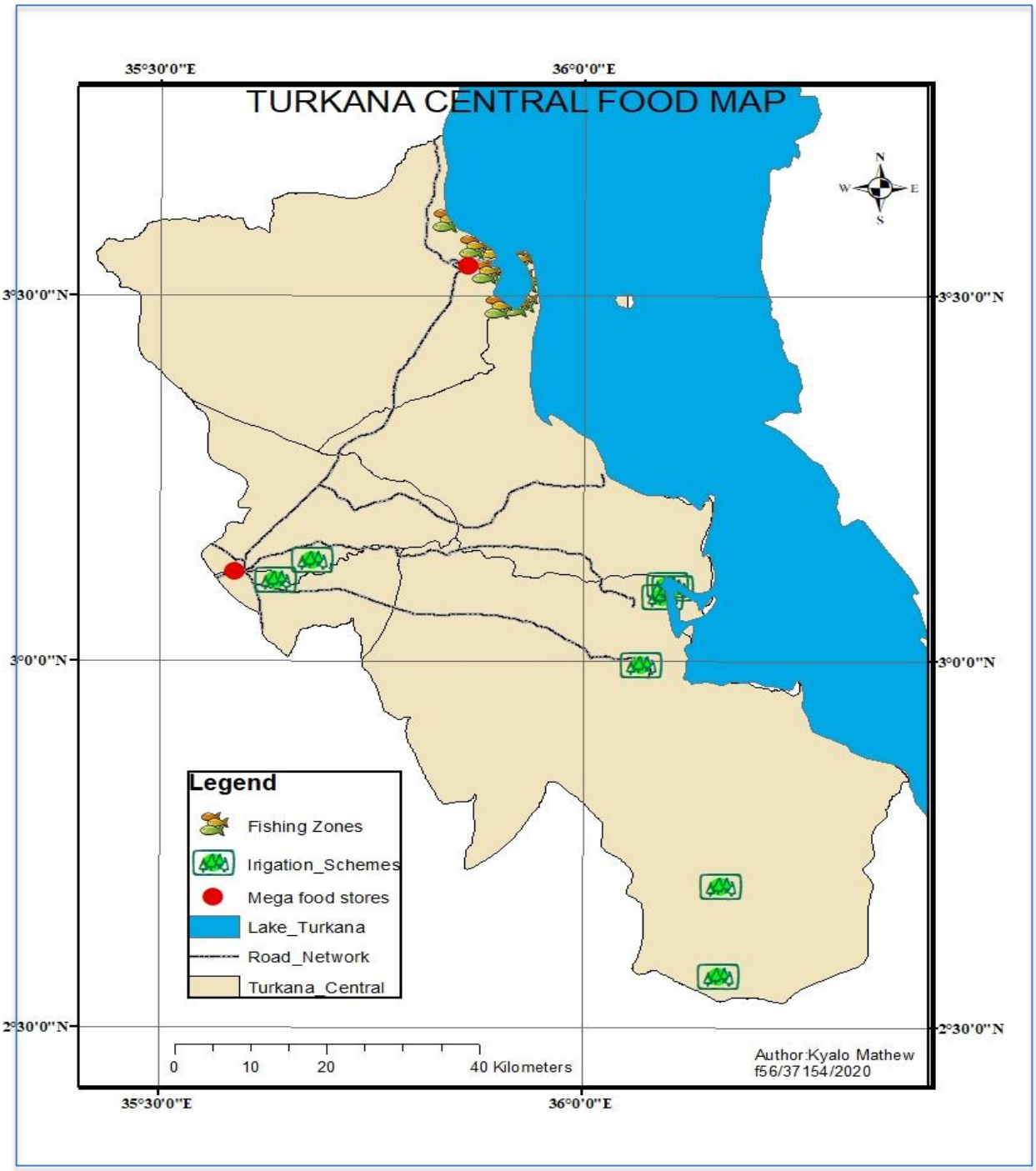


Figure 1 33 Food map

Above is a map showing production and storage sites for food in Turkana County, together with the existing official roads.

CHAPTER 5: CONCLUSIONS AND RECCOMENDATIONS

5.1 Conclusions

The main reason for carrying out this study was to be able to develop food maps and gather together food related data so as to help guide individuals and institutions willing to help curb hunger in Turkana Central Subcounty and apply the same technique in solving the issue of food insecurity in other areas similar to Turkana.

For the above to be achieved, specific objectives had to be put in place and they included;

a) Create a geospatial database that holds all food information together.

b) To map Sources of food in Turkana Central.

c)To create a map showing food transportation routes.

d) Map food storage facilities in Turkana Central.

Therefore, it can be concluded that;

a) A geospatial database holding food information together was created successfully.
b) Food sources in Turkana Central were mapped.
c) Maps showing food transportation routes were created.
d) Food storage facilities in Turkana Central were created.

In the introductory part of this project, the need for food mapping in Turkana was made clear since food mapping has been carried out in different places of the world and embracing the resolutions given after completion of food maps and findings has always led to better supply and accessibility of foods, food maps have also previously guided planners and institutions in their activities hence led to societies that could be able to sustain their people in terms of food accessibility.

5.2 Findings

Some of the challenges facing food production in Turkana despite past efforts by a number of institutions to help in production of food include:

When it comes to irrigation schemes, it was noted that during dry seasons, people drive their animals inside the farms hence end up destroying and eating other people's crops. This is as a result of the don't care attitude with most residents having the mindset that since they were earlier on surviving via pastoralism hence, they don't need crop farming.

Some of the schemes are not well accessed by roads and at times the earth roads are impassable

The level of insecurity in this area is quite high due to civilians being in possession of AK47 guns, some of these guns had been given to the police reserves but find themselves in civilian possession hence banditry is a norm in this area, business men and aid organizations travelling to this area have a couple of times been attacked on their way to Turkana and at times lives are lost.

Some community members at times use the money supposed to be used for purchase of farm produce in payment of their children's school fees, hence they opt to sacrifice agriculture for their children's education.

The reason that all the land area available for irrigation is not utilized to its full potential is due to lack of adequate funds for the establishment of the irrigation infrastructure.

When looking at fish produce from lake Turkana it was found out that the fishing lodge size is reducing due to rise in water levels that is also submerging the BMUs.

Also, the number of fish that the fishermen are able to fish cannot be processed wholly due to the capacity of the existing Cold chain facility that can only be able to handle 4 tons of fish per week while the total amount of fish produced is 6 tons per day. This in return leads to the fishermen selling their fish at very low prices for as low as 30 bob per kg and hence it translates to their poor livelihoods due to poor pay.

5.3 Recommendations

After completion of the study, the below recommendations were advised

I. The county planning committee to lead in changing the management of the irrigation schemes and re instate a serious committee to take charge of the schemes especially when it comes to Napuu irrigation scheme.
II. Educating the community on the importance of irrigation and how smart farming can be done hence changing the community mindset since most of them only believe in pastoralism and as a result they assume that anything other than pastoralism is a government project which most are less receptive to embracing.
III. Research should be done on rise in Lake Turkana Water levels since in a few years the fishing Lodge might be completely submerged, this research should help come up with mitigation measures and alternative sites for setting up fishing facilities.
IV. Frequent community meetings to be held so as to help sensitize the Turkana community on the importance of crop farming and also teach the people of Turkana on modern ways of farming hence ensure production of more food.
V. Fence irrigation schemes using chain link since those schemes that have natural fences as thorns can be easily bypassed by headers, later on after harvesting the fenced farms can be opened up for animals to eat on the farm remains
VI. The county government to support the farmers, even if it means giving some fertilizers and help maintain water storage facilities as some of the equipment might be extremely costly to replace and maintain.
VII. Institutions, Governmental and Non-governmental organizations as FAO and the County government of Turkana should help provide technical support to farmers in terms of hiring or contracting qualified and competent personnel to help in study of crop pests and diseases, improve on farm yields together with providing more Ver tertiary officers.
VIII. The National and County governments to help construction of good roads and maintaining of earth roads so as to aid in transportation of farm produce and farm inputs as fertilizers,
IX. Create a favourable condition for business people dealing with food in these areas.
X. The National and County assemblies should create bills that ensure that foods that will be produced in productive lands can be moved to unproductive lands, this can be by improving transport routes, fully devolving food matters hence give governors full control of matters food.

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Appendices

Image 1 36 Lake Turkana Fishing Lounge

Image 1 37 Animal sale yard

S/No.	Name of irrigation scheme	Ward	Area under irrigation	Total irrigation Potential	Type of irrigation	Dominant type of crop grown	No. of farmers	No. of households	latitude	longitude
1	Naoros	Kangatotha	400	750	Basin	Maize and sorghum	910	2693	3;6;4.332	36;6;1.464
2	Nadoto	Kerio delta	700	1,080	Basin	Maize and sorghum	857	3,428	3;5;3.384	36;5;39.036
3	Nakoret	Kerio delta	528	900	Furrow	Sorghum & cowpeas	650	2600	2;41;18.760	36;9;50.840
4	Kangirisae	Kerio delta	30	2000	Furrow	Sorghum & cowpeas	100	400	2;33;59.22	36;9;40.96
5	Nangitony	Kerio delta	350	800	Basin	Maize and sorghum	612	1847	3;5;50.304	36;6;21.798
6	Ngimuria	Kerio delta	1,367	3,750	Rain fed	Sorghum & cowpeas	1,268	2066	2;59;27.33	36;4;5.74
7	Kakwanyang	Township	300	820	Basin	Maize and sorghum	400	1024	3;8;2.916	35;40;50.922
8	Napuu 1 drip	Kanamkemer	65	280	Drip irrigation	Kales, spinach, water melon	418	1508	3;6;28.026	35;38;16.962

Table 2 Summary of Irrigation schemes

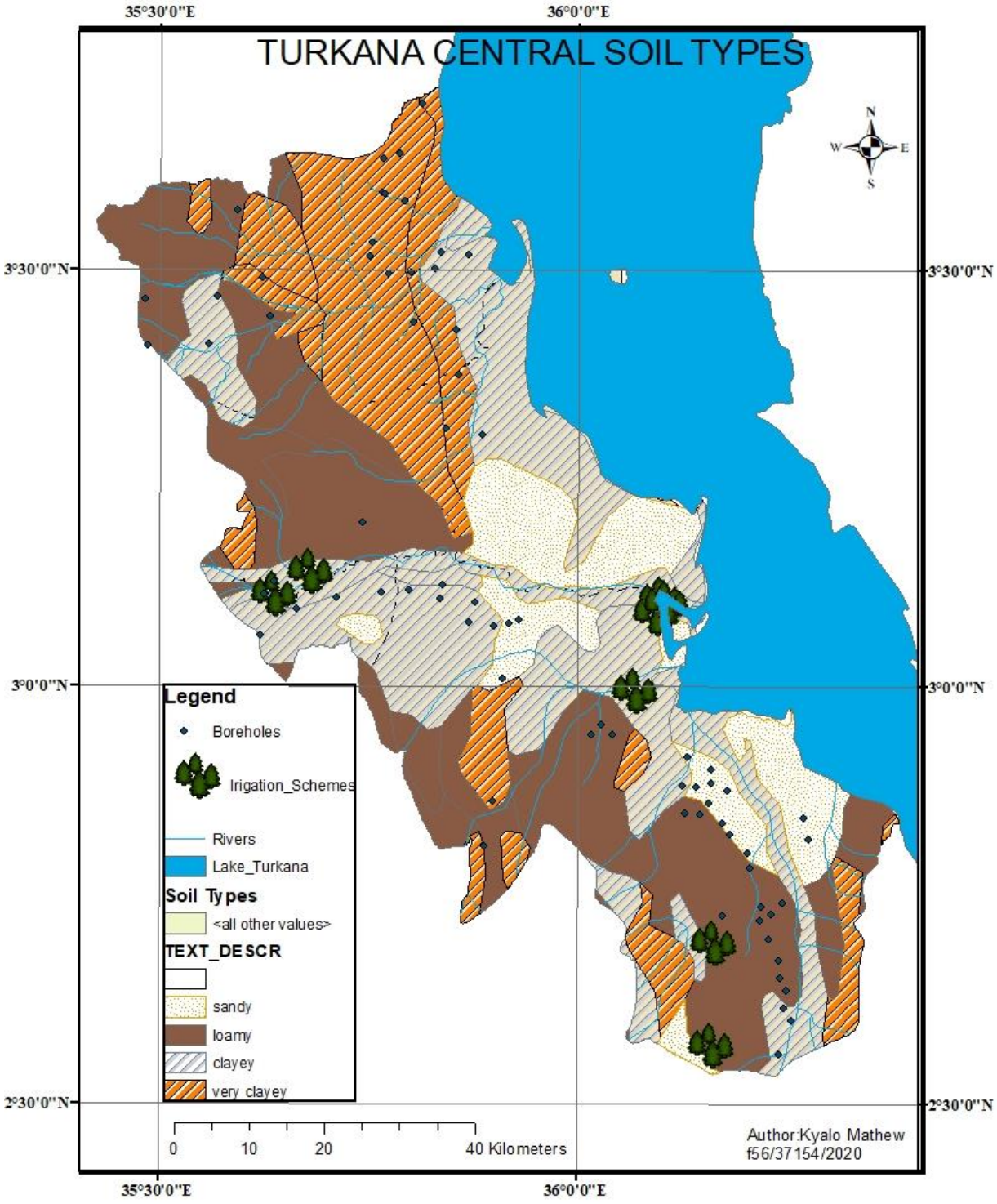

Figure 1 34 Irrigation schemes in relation to water points and soil types

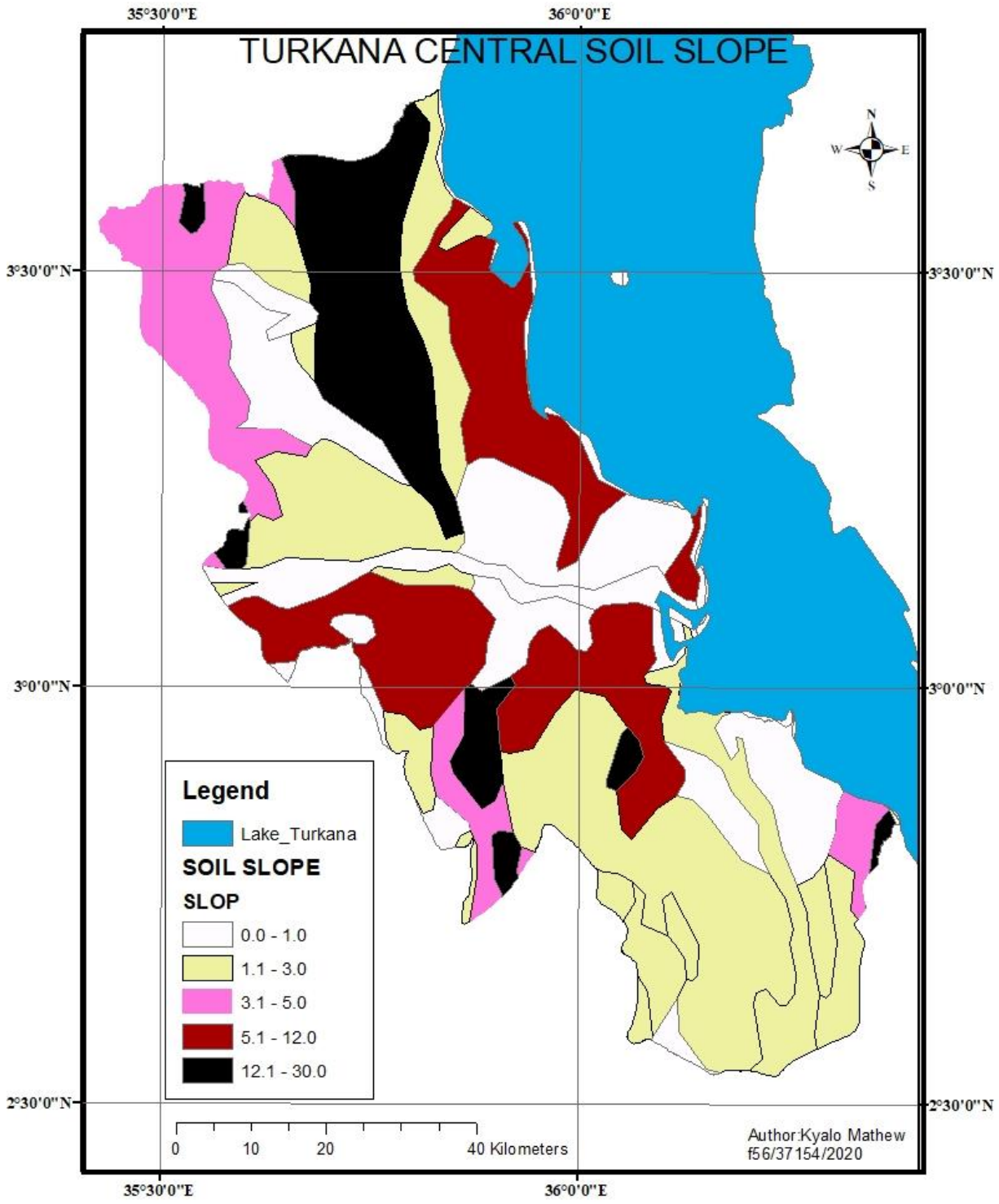

Figure 1 35 Irrigation schemes in relation to soil slopes

Image 1 38 *Picture of Napuu irrigation scheme*

Image 1 39 Picture of Napuu irrigation scheme entrance

Image 1 40 Picture of Kakwanyang irrigation scheme

Image 1 41 Picture of a borehole in Turkana Central