MAPPING OF PLANT AND NON-PLANT BASED FOREST FOOD RESOURCES IN MAFINGA DISTRICT USING PARTICIPATORY GEOGRAPHIC INFORMATION SYSTEMS (PGIS)

By

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A dissertation submitted in partial fulfilment of the requirements for the degree of Masters of Science in Geographic Information System and Earth Observation

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DECLARATION

I, Chilende Edward declare that this dissertation represents my own work, and that it has not previously been submitted for a Diploma, advanced Diploma, Bachelor's Degree or Master's Degree at The University of Zambia or any another University in the world. Works done by other researchers have been acknowledged.

Sign…….

Date……

CERTIFICATE OF APPROVAL

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ABSTRACT

Forests play an important role in enhancing food security by providing a diversity of food resources and other food production services for human beings. Despite this critical role that forests play in food systems, especially for developing countries such as Zambia, forests are often sacrificed for other developmental projects and land uses such as infrastructural development, mining and agricultural activities. This problem is worsened by a lack of proper presentation of the spatial distribution of forest food resources on the existing forest maps in Zambia. Thus, hot spots for forest foods such as mushrooms, roots and tubers, honey, wild fruits, insects and wild vegetables are largely ignored and therefore not considered by spatial planners and decision-makers on land use and development strategies. This situation could compromise local and national food security. This study aimed at mapping forest food resources in Mafinga district of Muchinga province in Zambia so that types of forest foods available in the region could be identified, their seasonal availability is known and their spatial distribution could be displayed on the map. The study used Participatory Geographical Information System (PGIS) to ensure that indigenous knowledge was tapped and used in the mapping of forest food resources in three chiefdoms of Mafinga district namely Muyombe, Mwenechifungwe and Mwenewisi chiefdoms. This study firstly identified the availability of the forest food resources; secondly assessed the seasonality of these food resources and thirdly provided input for mapping of food resources in the study area. A total of 144 participants (50 % women and 50% Men) who have lived in the area for more than 10 years was purposively selected for PGIS Mapping. The data collection instrument that was used was an interview guide administered while conducting a transect walk. With the use of a Global Positioning System (GPS) and topographic map, data was also collected. Thereafter, data was analyzed and mapped using ArcMap 10.3. The study identified 48 different types of forest food resources which were categorized into 6 major groups namely fruits, vegetables, mushrooms, roots and tubers, honey and insects. The majority (69%) were wild fruits followed by vegetables with 19%. Tubers and roots as well as mushrooms had 4% each while insects and honey had 2% each. In terms of seasonality, the results show that about 50% of the forest foods are available during the rainy season, 27% of them are available during the dry season, 6% of them are available towards the end of the rainy season and early dry season, 2% are available towards the end of the dry season and early rainy season and about 15% of them are available throughout the year. The participatory mapping showed that most of the forest food resources in Mafinga district are found in Tukuta forest reserve, Kapembe forest, Wimba woodland, Chapeluka forest reserve, Mayowa watershed and Chimung'onto forest reserve. The study concluded that participatory mapping is an essential tool for inclusive development and land use planning that can enhance the recognition of forest food resources in a region.

Key words: Participatory GIS, Forest Food Resources, Food Systems, Spatial Planning.

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TABLE OF CONTENT

CHAPTER ONE: INTRODUCTION 1

1.1 Background 1

1.2 Statement of the problem. 2

1.3 Main Objective 2

1.4 Specific objectives. 3

1.5 Research Questions 3

1.6 Significance of the study 3

1.7 Conceptual Framework 4

1.8 Theoretical Framework 4

1.9. Limitations 5

CHAPTER TWO: LITERATURE REVIEW 7

2.1 Introduction 7

2.2 Historical background of Participatory Geographic Information System (PGIS) 7

2.3 Major methods of mapping forest food resources 8

2.4 Techniques used in Participatory GIS 8

2.5 Participatory GIS and forest food resources 9

2.6 Types of forest food resources 10

2.7 Required soil for forest food resources 13

2.8 Research gap 14

CHAPTER THREE: STUDY AREA 16

3.1 Location 16

3.2 Climate 17

3.3 Socio-economic attributes of the study area 17

3.4 Physical characteristics. 17

CHAPTER FOUR: RESEARCH METHODS 20

4.1 Research Design 20

4.2 Sampling Frame 20

4.3 Sample Size 20

4.4 Sampling techniques 20

4.5 Sources of Data 21

CHAPTER FIVE: RESULTS AND DISCUSSIONS 22

5.1 Identification of plant based and non - plant based forest foods. 22

5.1.1 Fruits 22

5.1.2. Vegetables 27

5.1.3. Honey 28

5.1.4. Insects 31

5.1.5 Mushroom 31

5.1.6 Roots and tubers 32

5.1.7 Summary of types of forest food resources in Mafinga 33

5.2 Seasonality of forest foods in Mafinga district. 33

5.2.1 Rain season 34

5.2.2 Off rain season 35

5.2.3 Throughout the year 36

5.2.4 Rainy-Dry season 37

5.2.5 Dry-Rain season 38

5.3 Spatial distribution of forest foods in Mafinga District using Participatory GIS (PGIS). 39

5.3.1 National Parks and National Forest Reserves distribution in the study area. 40

5.3.2 Forest food hotspot areas. 42

5.3.3 STUDY VALIDATION OF THE FOREST FOODS SPATIAL DISTRIBUTION. 50

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS 52

6.1 Conclusions 52

6.2 Recommendations 53

REFERENCES 54

APPENDICES 57

APPENDIX I 57

STRUCTURED INTERVIEW GUIDE 57

SEMI-TRUCTURED INTERVIEW GUIDE 59

LIST OF FIGURES

Figure 1: Conceptual Framework 4
Figure 2: Study Area Map..... 16
Figure 3: Soil types in the study area..... 19
Figure 4: Fruits in Mafinga District..... 23
Figure 5: Burnt fruit trees 27
Figure 6: A tree where bees produce honey..... 29
Figure 7: Tamed bees in a log of a tree in Tukuta Forest Reserve of Chief Mwenewisi 30
Figure 8: Percentage representation of forest foods in Mafinga district..... 33
Figure 9: Forest foods available during rainy season in the area..... 35
Figure 10: Forest foods available during dry season in the area..... 36
Figure 11: Summary of seasonal availability of forest foods in Mafinga district 39
Figure 12: Landsat image of Mafinga district..... 40
Figure 13: National Parks and National Forest Reserves in Mafinga District..... 41
Figure 14: Spatial distribution of forest foods in Mafinga chiefdoms..... 43
Figure 15: Soil types in forest food areas 45
Figure 16*:* Map showing forest foods areas near villages 47
Figure 17: Spatial distribution of types of forest foods in Mafinga district..... 49

LIST OF TABLES

Table 1: Types and location of fruits in Mafinga district. 24
Table 2: Summary of seasonal availability of forest foods resources in Mafinga district..... 39
Table 3: Summary of the coverage area of forest foods in Mafinga district 50

LIST OF ACRYNOMS

GIS	Geographic Information system
GPS	Global Positioning System
QGIS	Quantum Geographic information System
PGIS	Participatory Geographic Information system

CHAPTER ONE: INTRODUCTION

1.1 Background

Forests play an important role in enhancing food security in societies both directly and indirectly (Food Agriculture Organisation, 2016). International Union of Forest Research Organisation (2015) puts it clear that from the ecosystem services point of view, forests contribute directly to food security mainly through provisioning services where forests provide food, supply water, firewood, fiber, timber and many other plants which are useful to humans. On the other hand, forests contribute to food security indirectly through regulating services (Arnold et al., 2011). These are service where forests control the climate and some plant diseases (Lita and Eric, 2012). Supporting services are another way in which forests contribute indirectly to food security as forests promote nutrient circles and the production of oxygen in the ecosystem (Glasmeier and Farrigan, 2005).

Despite a variety of services being offered by forests, developing countries such as Zambia sacrifice forests for other developmental projects and land uses such as residential, agriculture and infrastructural development (Ministry of Lands and Natural Resources, 2017). This has consequently caused the contribution of forests towards food security not to be among the top agenda in decision making in Zambia. This is evident enough by the lack of maps showing forest food resources in Zambia which could have been important tools in decision making in the zoning of land use designation. This study was done using Participatory Geographic Information System (PGIS) to map forest food resources in Mafinga district of Muchinga province in Zambia. The study used Participatory Geographic Information System (PGIS) because it is the decision-making tool that integrates local knowledge, supports the exchange of information, discussion and negotiation among the stakeholders to rectify, refine and resolve spatial problems (Radial and Anderson, 2016).

This study was done in a manner where local people were involved in identifying the areas where forest food resources are available in the study area. It should be noted that this is not the first study in Zambia which used Participatory GIS with the incorporation of indigenous knowledge. Dale (1995) indicates that a similar study about the importance of community-based wildlife management was done in Mfuwe district. Dale (1995) asserts that local people in villages surrounding Mfuwe national park were used to assess the management of local animals in the park using ArcInfo software. The results of the study offered a growing set of achievements in land use

planning by local community leaders in support of the local people of Mfuwe. It is also worth noting that the maps that were produced after the study were used by the local authority to explain and build consensus at the community level on ways to resolve resource use conflicts and further train residents to participate in the collection of GIS data as a way of making maps more locally acceptable and better focused on relevant issues and needs in the community (Dale, 1995).

The results of this study demonstrated that PGIS is an effective tool in the management of communal resources as it focuses on relevant issues needed in the community to enhance national development in the planning realms. The results further demonstrated that PGIS is an effective tool to manage community-based resources because it is usually community empowered and includes local knowledge in the discussion of development. Dale (1995) also states that the results of his study showed that PGIS incorporates divergent views of local people which would be of great importance in the implementation of developmental projects in a community. If PGIS is effectively and efficiently used, it can enhance the conservation of forest food hotspots and ensure that forests are more productive and fruitful to the local people and enhance food security in the region and the country at large.

1.2 Statement of the problem.

Zambia has experienced high levels of national forests being changed to other land uses such as agriculture and residential land uses. Kasaro and Fox (2017) put it clear that despite 60 percent of the Zambian territory being covered by forests, about 300 000 hectares of land is being changed to other land uses every year. Ministry of Lands and Natural Resources (2017) states that the rate at which forests are being deforested would lead to the potential loss of 10 million hectares of forests in the next 30 years. Massive deforestation and degradation of forests in Zambia is a clear indication of less attention being paid by the government and the local authorities on the importance of forests towards food security. There are no maps showing forest food resources in many forests across the country (Kasaro and Fox, 2017). The unavailability of forest food maps compromises food security especially in local communities in the country because there is no proper basis upon which forest food resources can be protected and preserved.

1.3 Main Objective

To develop a map showing the spatial distribution of forest foods in Mafinga district using Participatory Geographic Information System (PGIS).

1.4 Specific objectives.

i. To identify forest foods in Mafinga district.
ii. To assess the seasonality of forest foods in the study area.
iii. To map the spatial distribution of forest foods in the region using Participatory GIS (PGIS).

1.5 Research Questions

i. What plant-based forest foods are found in Mafinga district?
ii. What non-plant-based forest foods are found in the Mafinga district?
iii. How do seasons influence the availability of forest food resources in the region?
iv. How are forest foods distributed across the study area?

1.6 Significance of the study

After types of forest foods have been identified in the region and their spatial distribution mapped, it would be easier for the government and other interest groups to protect them for the benefit of the local people and the country at large.

The mapping of forest food resources in Mafinga would also attract investors who might be interested in extracting or processing local forest food resources in Mafinga district and community-based investment will be enhanced in the region. This can consequently improve the standard of living of the local people.

The other significance of this study is that it will lead to employment creation in the region. The incoming of investors who would want to extract and process local forest food resources in the region will enable local people to be employed in industries that are going to be extracting and processing local forest foods. Employment creation would further lead to poverty reduction in Mafinga district as local people will be able to meet their daily basic necessities.

This study will also promote value addition of local products as it is going to show the abundance of forest foods in the region which will in turn attract numerous investors in the region. Forest foods that are found in Mafinga are going to be processed by investors and their value will be increased. Value addition of forest foods would lead to the rising of prices of local products and this would strengthen the economy in the region.

This study will also promote the preservation of local forest food products as areas which are hotspots of forest foods will be identified and protected. This will prevent the extinction and disappearance of local forest food resources for the future generation.

1.7 Conceptual Framework

There are a number of forest food resources provided by forests in communities. Some of these forest food resources provided by forests include honey, fruits, insects, vegetables, roots and tubers. These forest food resources are sources of dietary needs because they are a source of food and some of them have medicinal uses to human beings. The fact that these forest foods are a source of food and have medicinal uses, they promote food security and good health respectively to a diversity of humans. *Fig 1* shows the conceptual framework illustrating the importance of forests in societies.

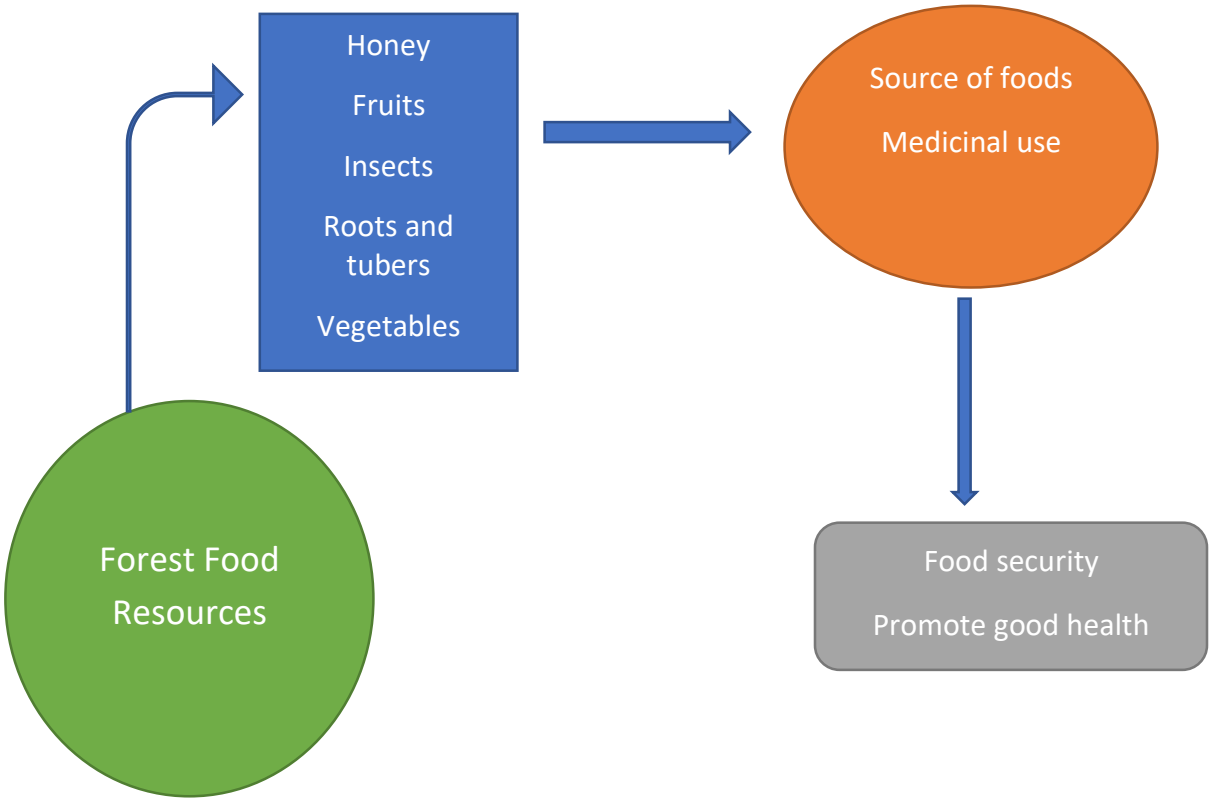

Figure 1: Conceptual Framework

1.8 Theoretical Framework

The Permaculture Theory states that forest foods grow in seven recognized layers for a diversity of human beings to benefit from them (Ana, 2002). The theory states that because plants grow in

different heights, a diverse community of life can to grow in a relatively small space as the vegetation occupies different layers (Lita and Eric, 2012). Glasmeier and Farrigan (2005) are of the view that the seven recognized layers of forest foods include the canopy, understory, shrubs, herbaceous, ground cover, Rhizosphere and vertical layer. The theory stipulates that the canopy layers are tall trees that grow in forests and the understory layer are trees that are under the canopy layer. Shrub layers are wood perennials of limited height and herbaceous layers are dwarf plants that die every cold season due to coldness. On the other hand, the groundcover layer has plants that grow much closer to the ground and grow closer to the bare patches of the ground. The Rhizosphere layer has plants that grow within the soil such as roots and other edible tubers. The vertical layer has climbers or vines that climb a particular plant during the growing process. Lita and Eric (2002) contend that from the permaculture theory point of view, each forest food falls under one of the seven recognized layers in forests. For these layers to effectively and efficiently grow, the theory stresses the need for three ethics namely care for the earth, care for people and fair share (Glasmeier and Farrigan, 2005). The permaculture stresses the need to care for diverse forms of life such as animals and plants found in the forest. In the process of caring for the earth, the care for humans will occur naturally and there should be fair sharing of resources where there should be equality between the rate of consumption and restoration of natural resources should be promoted. This can be done by restoring the vegetative system by planting vegetation and improving soil health (Lita and Eric, 2002). In summary, the Permaculture states that forest food resources grow in seven recognized layers and for each of these layers to work effectively and efficiently, there should be care for the earth, care for humanity and fair share through conservation of natural resources to enhance the sustainable growth of forest foods within the forests in every community (Glasmeier and Farrigan, 2005).

1.9. Limitations

Language barrier is one of the challenges that were encountered during this study. The local languages in Mafinga district are Tumbuka, Lambia and Nyika. The fact that the researcher is not conversant with Tumbuka, Lambia and Nyika, it was difficult to communicate with the local people. However, this challenge was overcome by engaging local interpreters who were interpreting for the researcher and the respondents during data collection in the field.

Means of transport was another challenge that was encountered during this study. It was not easy to move from one place of Mafinga to another due to limited means of transport and poor road

network. However, this challenge was addressed by hiring a motor cycle that facilitated the researcher to go around the study area during data collection in the field.

The other challenge which was encountered during this study was the unavailability of respondents in their homes in the morning hours. Many local people were not available in their homes in the morning as they were busy harvesting food crops in their fields. However, this challenge was addressed by collecting data in the afternoon after they had been knocked off from their fields. The other way in which this challenge was addressed was by making prior arrangements of visiting the respondents in their homes.

The other challenge encountered during the study was the suspicion that the researcher was from the Forest Department. Local people suspected that the researcher was from the Forest Department and the respondents were initially hesitant to give him the relevant information on the types of forest food resources in the study area. However, this challenge was resolved by producing the introduction letter from The University of Zambia and the student identity card.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter will discuss what other scholars have done in relation to Participatory Geographic Information System (PGIS) and mapping of forest foods. It will begin by giving a brief background of Participatory Geographic Information System (PGIS), the importance of forests in food security and how Participatory Geographic Information System can be used in enhancing food security in a society.

Geographical Information Systems (GIS) are defined as an organised collection of computers hardware, software, geographical data and personnel designed to efficiently capture, store, update, manipulate, analyse and display all forms of geographically referenced information (Elwakil, et al, 2015). It is a collection of computer hard ware and software that are designed to capture, store, update, manipulate, analyse and display geographic data for easy interpretation.

Radil and Anderson (2016) are of the view that Participatory Geographic Information Systems (PGIS) which is sometimes referred to as soft GIS is a technique that usually involves the use and application of geo-spatial information and GIS technologies that allow members of the local community to participate in spatial decision processes that affect their daily lives. Huisman and By (2009) state that PGIS is driven by two forces namely community empowerment and innovative data collection among community members.

2.2 Historical background of Participatory Geographic Information System (PGIS)

The term PGIS was introduced in the mid-1990s to emphasize the use of GIS as a tool for promoting community involvement in the decision-making processes and to promote community participation in the collection of geographic data and production of maps within the community (Radil and Anderson, 2016). Rebecca (2017) indicates that Participatory GIS, which is also known as soft GIS is a discipline whose main goal is to include participatory information and the use of local knowledge in planning practices, decision-making processes and long-span developmental processes. Huisman and By (2009) strongly stress that decision making in PGIS involves the exchange of information, discussion and negotiation among the stakeholders to clarify, refine and resolve spatial problems of developmental projects and programs in the local community. Radil and Anderson (2016) argue that this should be noted to be the major aspect that makes PGIS a potential informative tool for use by policy makers and town planners in communities. It should

also be noted that PGIS involves the production of maps, through the use of GPS technology in the collection of spatial data and the production of a map should be carried out by the community members without much help from GIS experts (Radil and Anderson, 2016). It should also be known that the involvement of the local community in the decision-making processes and the production of maps helps the local authorities in the promotion of good governance and the upholding of good governance principles of inclusiveness, transparency, efficiency, appropriateness and ownership (Huisman and By, 2009)

2.3 Major methods of mapping forest food resources

European Commission (2014) argues that there are two major methods of mapping forest food resources. These two methods are Remote Sensing method and Participatory GIS method. The Remote Sensing method uses satellite images while Participatory GIS uses indigenous knowledge from local people. However, European Commission (2014) indicates that the Remote Sensing method requires high spatial resolution satellite images to avoid omission of forest food hotspot areas. This method is only reliable if the researcher has access to high spatial resolution satellite images (Gascón & Eva, 2014). On the other hand, the Participatory GIS method of mapping forest foods uses a handheld GPS while conducting a transect walk around the community (European Commission, 2014). This method is highly reliable because the local people have full knowledge of the actual locations of forest food resources and it is not exposed to errors. Based on this principle, this research used Participatory GIS to capture reliable data from the local people during a transect walk (Cooper, 2019).

2.4 Techniques used in Participatory GIS

It should also be noted that Participatory GIS uses different techniques. Radil and Anderson (2016) indicate that the prominent techniques used in Participatory GIS are using a hand held GPS while conducting a transect walk and pegging of locations on a topographic map, geo-reference the map and then digitising it. Dale (1995) also indicates that the other techniques used in PGIS is sketch maps and use of high resolution imagery. Pegging on a topographic map has errors attached to it in the sense the local people might misplace the pegs on the map and make wrong digitization. Conducting a transect walk using a handheld GPS is a reliable technique because the actual areas of interest are visited by the researcher and the local people, hence the use of the transect walk technique in this research (From百度文库, 2013).

It is worth noting that numerous studies on Participatory GIS have been done by numerous scholars across the world. One of the researches was done in Mfuwe district of Zambia to assess the importance of GIS to community-based management of wildlife. The results of the study showed that Participatory GIS forms strong bedrock towards the conservation of community-based resources such as forest foods and wildlife. This is because it captures indigenous knowledge from local people which enable them to realise the importance of conserving resources within their localities. The study further revealed that the promotion of PGIS technologies and applications will never create any doubt towards reshaping of landscapes, natural resources management and attainment of sustainable development (Dale, 1995). Besides that the study revealed that Participatory GIS helps improve the capacity of rural communities to become more knowledgeable and effective in managing their available resources such as wildlife, forest foods, timber and many other local resources that would need conservation and preservation for the future generation.

2.5 Participatory GIS and forest food resources

Ana (2002) argues that PGIS is an effective tool to map forest food resources in an area. Ana (2002) points out that PGIS is an effective tool to do that task because local people are the ones who know the distribution of the resources within their local forests. International Union of Forest Research Organisation (2015) defines forests as a large area dominated by trees, shrubs and grass. It is an area dominated by a variety of species of trees. Food and Agriculture Organisation (2016) defines forest food resources as edible products that require little or no cultivation and grow "naturally" as part of a forest ecosystem. In other words, forest food resources are edible products from the bush that grow naturally and do not require any cultivation or protection during growth.

Parotta (2016: 73) indicates that "Forests and tree-based systems are an important component of rural landscapes, sustaining livelihoods and contributing to the food security and nutritional needs of hundreds of millions of people worldwide." Food Agriculture Organisation (2013) also contends that forests are a direct source of food, cash income and a range of subsistence benefits for millions of people worldwide. Food and Agriculture Organisation (2016) states that despite the incomplete provision of diet, forest foods make a critical contribution to the supply of food to the local people. Mary and Nigel (1996) state that in many African societies, forest foods provide a diversity of minerals, vitamins and nutrients in the diets of many local communities. An example given is Tanzania where 92% of the 389 households surveyed by Frances and Salisu (2003) collected and gathered edible wild foods to earn a living. Frances and Salisu (2003) further state that this makes

forest foods to be an important element in times of food shortages. This implies that forests play a pivotal role in promoting food security world-wide due to the number of forest foods that are found in the forest. Arnold et al (2011) contend that forest foods also play an important role to children to ensure good growth and physical development. Besides that, Frances and Salisu (2003) strongly assert that forest foods are also important to women who are seeking to conceive, those that are pregnant and those that are breastfeeding because of their nutritional values. Obua et al (1998) also point out that forest foods are also important to elderly people who are weaker and more susceptible to diseases.

Frances and Salisu (2003) also contend that forest foods play a pivotal role in enhancing the economy. This occurs when forest food resources are collected and traded by the local people to meet their basic needs in their homes. Frances and Salisu (2003:24) indicate that "in addition, they provide an opportunity to generate income when they are collected and traded". This indicates that forest food resources also play an important role in enhancing the economy of a region as they are collected and traded by the local community to meet their socio-economic needs. In other words, the literature strong show that not only are forest foods important for food security but also to children, women who are pregnant and breastfeeding as well as old people who are susceptible to a diversity of diseases because of the nutritional values which they contain. Besides that, forest foods also play an important economic role by generating income when they are traded by local people.

France and Salisu (2003) assert that the importance of forest food increases in times of famine. This is because the communities heavily depend on forest foods availability to earn a living. Arnold et al (2011) content that this is the period when forest food resources become more vital to the society because even the poor population of the society can find food to eat by either selling the forest foods and buy food or direct consumption of forest foods available in the locality (Udaya Lakshmi et al., 1998).

2.6 Types of forest food resources

There are several food resources that are found in forests. Hari (2013) states that some of the food resources that are found in the forests include honey, mushrooms, wild fruits, wild animals, roots, wild leaves, tuber, saps, gums, fish, insects, birds and their eggs and many other products from the bush. Lita and Eric (2012) point out that some of the forest foods that are found in other parts of

the world such as in the Pacific North-west are berries such as blackberry, elderberry, huckleberry, lingonberry, Palm berry, Oregon grape and wild plum. Lita and Eric (2012) further indicate that other forest foods found in forests included fungi, green tubers, syrups, flavourings, seeds and nuts.

One thing that Frances and Salisu (2003) found in their study is that some of the forest food trees produced more than one forest food. "Some plants produced more than one edible product" (Frances and Salisu, 2003:26). In their study, the results clearly show that some of the plants in their study area produced a variety of forest foods such as edible flowers, seeds and fruits at the same time. This clearly shows that some plants around this world produce more than one forest food at the same time. Frances and Harris (2013) further grouped the forest food resources into five categories according to how they are used. These major groups are fruits, vegetables, honey, insects, roots and tubers.

Hari (2013) further indicates that these forest foods supplement foods produced in the agricultural system and this contributes positively to food security. Glasmeier and Farrigan (2005) point out that rural citizen in many countries around the world depend on forests to earn a livelihood. Glasmeier and Farrigan (2005) give an example of America where rural Americans derive most of their livelihood from forests.

Frances and Salisu (2003) state that some of the forest foods have side effects to consumers in the community. "Of the wild foods identified, 15 were said to cause side effects if taken in excess. Usually, the side effects were stomach problems: stomach ache, vomiting, diarrhoea or constipation" (Frances and Salisu, 2003:26). It was found that most of the forest foods that had side effects if taken in excess were roots and tubers. An example given of the forest food that would bring vomiting if taken in excess was the root of young *Hyphaene the Baica* plant. Frances and Salisu (2003) stress that this root causes severe vomiting and constipation when taken in excess. Some individuals in northern Nigerian could remember how this root made them sick to the point of death due to excess intake of it (Frances and Salisu, 2003). This indicates that some of the roots and tubers are dangerous if taken in excess by consumers.

Frances and Salisu (2003) content that despite the availability of numerous forest food resources around the world, there is a curve of decrease in quantity due to human activities such as deforestation. Some human activities such as agriculture have led to the loss of forest food resources in many regions of the world as trees that produce forest foods are cut down during

traditional methods of farming. Frances and Salisu (2003) state that most of the forest food resources in northern Nigeria were cut down and burnt by farmers who wanted a large area for their traditional way of farming due to population increase in the region. Arnold et al (2011) also highlight that many forest food resources around the world finish due to certain human activities such as poor farming methods. Arnold et al (2011:261) state that "in some regions, natural forest foods are being replaced with plantations, tree crops or farm trees which provide less diversity dietary inputs to food sources from forests". This clearly shows that most of the forest foods in the forests get finished due to certain human vices such as bad farming methods or prioritizing certain plants to forest foods. It can therefore be argued that most forest food resources in many regions of the world finish due to certain human activities such as bad farming methods like certain traditional farming methods that demand the clearing of trees to grow crops.

Frances and Salisu (2003) grouped the seasonal availability of forest foods into 4 categories namely pre-rainy season, rainy season, harvest season and dry season. However, it should be noted that the fifth category of seasonal availability of forest food resources is that of throughout the year. Frances and Salisu (2003:26) state that "there are wild fruits available at all times of the year, although they are not many". This indicates that in addition to the 4 categories of seasonal availability of forest foods, there is one category of throughout the year which then makes the total of 5 categories of seasonal availability of forest food resources.

Lita and Eric (2013) indicate that most of the forest foods around the world are available during the rainy season. Frances and Salisu (2003:26) argue that "the rainy season is defined as the period from the first planting rains to the end of rains". This implies that forest foods that are available during the rainy season are ready for consumption around the time of the first rain to the time of the last rain of the planting season. Frances and Salisu (2003) also assert that most forest foods such as fruits, leaves and flowers are available in the rainy season when it is a hungry period and harvesting time is a long way off. This is because this is the season when water is available to enable them to grow in a conducive environment. Simulyamana (2017) indicates that many forest foods are not available in the dry season due to scarcity of water which leads to the drying up of some food resources. Simulyamana (2017) further indicates cold season also does not favour forest foods because most of them are dry due to coldness. Therefore, it can be stated that many scholars are of the view that most forest food resources are available during the rainy season because of the availability of water and favourable weather available during that time. On the other hand, most

of them do not survive in the dry and cold season due to drying up as a result of water shortage and coldness respectively.

2.7 Required soil for forest food resources

Lita and Eric (2012) state that most forest foods grow well in Lixisol type of soil. Lita and Eric (2012) put it clear that Lixisols favor the growth of forest foods because of their subsurface accumulation of low activity clay and high base saturation as they develop under intensive tropical weathering conditions (Food and Agriculture Organisation, 2013). It is worth noting that because of the decomposed materials that Lixisols contain, it can store enough water that enables the growth of forest foods. Food and Agriculture Organisation (2013) gives an example of mushrooms as forest foods that grow in areas with Lixisols because of their constituents such as weathered rock particles and decayed tree barks or leaves. It can therefore be strongly argued that most of the forest food resources grow in Lixisols because of their constituents which favor the growth of forest food resources.

Food and Agriculture Organisation (2016) also states that some forest foods are found in quiet areas that are not frequently visited by human beings. Food and Agriculture Organisation (2016) gives an example of honey as a forest food that is found in areas that are not frequently visited by human beings because generally, bees that produce honey do not like noisy places.

Food and Agriculture Organisation (2013) is of the view that most of the forest foods are distributed in hilly and mountainous areas. An example of forest foods found in hilly and mountainous areas are fruits such as berries, nuts and other types of fruits (FAO, 2013). From what many scholars have revealed, it can therefore be argued that most forest food resources are distributed in areas with Lixisols, quiet places which are not frequently visited by people and in hilly or mountainous areas.

Frances and Salisu (2003) stress that the major challenge that forest food experience is deforestation as a result of land-use change. Most of the forest foods are cut down when there is an agricultural activity that wants to take place or construction of infrastructure such as schools, hospitals and houses. Frances and Salisu (2003) contend that many parts of northern Nigeria had an increase in population which exerted more pressure on the land as more food crops were needed to feed the people. The need for more food led to massive cutting down of trees to clear land for agriculture which in turn led to the depletion of forest foods. Arnold et al (2011) state that in as

much as the society strives to feed its population by clearing large areas for agriculture, forest food hotspots should be preserved because forest foods also play a pivotal role in enhancing food security. Arnold et al (2011) stress that forest foods play a pivotal role in enhancing food security because forest food can either be sold to have money and buy food or they can be consumed directly by local people to stabilize the hunger situation in a community.

Having realized the importance of forest for food production, Udaya *et al.* (1998) point out that there is a need for optimal and efficient management of forest resources using reliable technology which ensures the use of tools such as Geographic Information System (GIS). Udaya *et al.* (1998) further indicate that the potential application of tools such as GIS derive a meaningful output and this can be used for decision-making purposes. Poratta (2016) states that Participatory Geographic Information System (PGIS) is a good approach to map the forest food resources in a particular area where community members are involved in examining the location of some community-based resources based on their spatial knowledge. Frances and Harris (2003) further highlight that PGIS becomes an appropriate approach to map local forest food resources because of the specific knowledge held by the local people about forest food. Besides that, local people have more opportunities of visiting areas where forest foods grow as they go to collect them for personal use or sale (Frances and Harris, 2003). Race (1999) is of the view that this can be done by utilizing Geo-Spatial management tools and methods such as sketch maps, aerial photographs, satellite imagery and Global Positioning System (GPS). Thus, there is a need to map the spatial distribution of forest food resources using Participatory GIS to efficiently and effectively manage forest resources in a locality. This is because Participatory GIS can help identify which type of forest food resource is located where and during which season of the year is it available in that locality (Udaya Lakshmi et al., 1998). Participatory GIS is an effective tool to do that task as it reliably uses indigenous knowledge from the indigenous people to map the available community-based resources. Rebecca (2018) strongly asserts that one important aspect of PGIS is that it is not a characteristic of an individual but a characteristic between them because its laying capabilities allow multiple voices and perspectives to be viewed simultaneously.

2.8 Research gap

Despite having a diversity of forests in Zambia, scholars have not mapped food resources found in forests. There are no maps in Zambia that show types of forest foods, their spatial distribution and the seasons in which these forest foods are available in our country. Therefore, this research

will narrow the gap by mapping the forest foods that are found in Mafinga District for the interest groups and stakeholders to know the types of forest foods in Mafinga District, their spatial distribution and the seasons in which these forests are available in the region.

It should also be noted that more research is needed across the country to identify the types of forest foods available in Zambia, assess the seasons in which they are available and map the specific location where every forest food is located in the country. This would enable the policy makers to know all the forest foods that we have in the country and where they are distributed across the country. Additionally, this will promote the conservation of forest foods in the country for the future generation.

Although Participatory GIS has been used around the world for various projects, the literature and publications remain quite sparse. This is because most Participatory GIS projects are done by NGOs and community groups who decide not to publish the results. However, this study will bridge the gap by publishing the findings and availing them to the relevant authority and all stakeholders to ensure that constructive measures are taken towards the conservation and preservation of forest food resources in Mafinga district.

CHAPTER THREE: STUDY AREA

3.1 Location

This study was done in Mafinga district of Muchinga province in Zambia. Mafinga district is one of the newly created districts which is located on Longitude 10º 35' South and Latitude 33º 28' East. It is located about 148 kilometers away from the great north road. The district is located in the eastern part of Isoka district of Muchinga province. It has a total area of about 3 919km^2 (Central Statistical Office, 2010)

This area was selected as a study area because it is one of the newly created districts in Zambia that are undergoing numerous developmental activities. This would lead to the destruction of forest food hotspots in the region, hence the need to map the available forest food resources in the region. There is a need for mapping of available forest food resources in the region to ensure that they are preserved and do not go extinct so that the future generation will see them too. *Fig 2* shows the geographic location of Mafinga district in Muchinga province of Zambia.

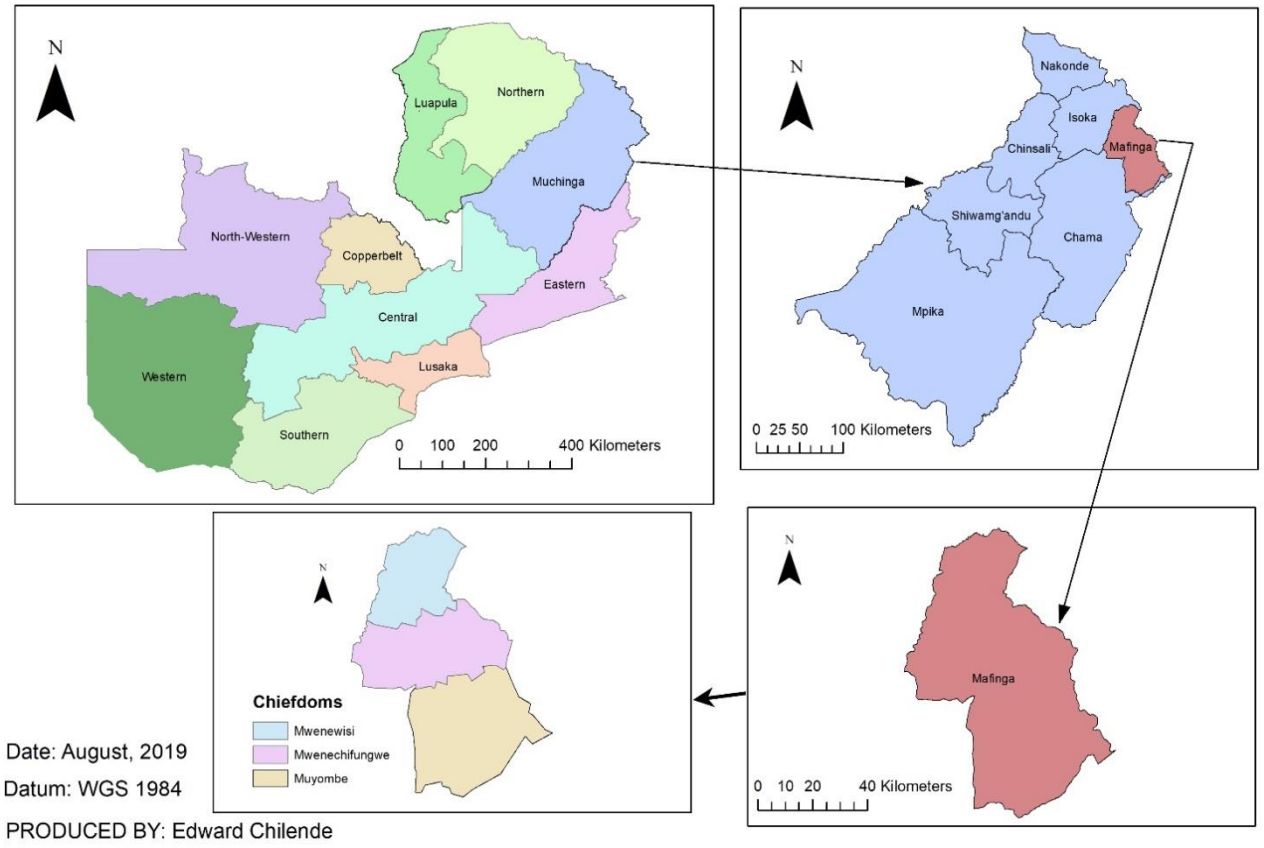

Figure 2: Study Area Map
Source: Mafinga District Council

3.2 Climate

The temperature in Mafinga District ranges between 15^0C and 23^0C (Bond, 2012). The average annual rainfall received in the region is about 1000 mm. The common type of rainfall received in the region is relief rainfall due to it being located in a mountainous area. The region is characterized by perennial streams that are mainly used for gardening. Most of the streams form a dendritic drainage pattern as they flow towards Luangwa River (Bond, 2012).

3.3 Socio-economic attributes of the study area

Bond (2012) puts it clear that Mafinga district has three chiefdoms namely Muyombe, Mwenechifungwe and Mwiniwisi. It has a total number of 255 gazetted villages (Bond, 2012). The total number of people living in Mafinga district is about 65,969 (Central Statistical Office, 2010). Local people grow food crops such as maize, beans, cassava, millet, sweet potatoes and rice. The local people also keep domestic animals such as cattle, goats, sheep and pigs. People in the region also conduct local trade as well as international trade with people from Malawi and Tanzania.
The dominant ethnic groups in Mafinga district are Tumbuka, Nyika and Lambia speaking people. The Tumbuka speaking people are occupying Muyombe chiefdom which is situated in the southern part of the district. The Nyika speaking people are occupying Chief Mwenechifungwe which is located in the central part of the district and the Lambia speaking people are occupying Mwenewisi chiefdom which is situated in the northern part of Mafinga district.

3.4 Physical characteristics.

Mafinga district is a mountainous area. Most parts of the district are characterized by mountains, streams, hills, tall trees, shrubs and rocks. Most of the relief in Mafinga District is made up of high veld which is land above 1200 meters above sea level. Some areas such as Mpalayi are as high as 2, 130 meters above sea level while the highest point in Mafinga District which is Mafinga hills is 2, 339 meters above sea level (Bond, 2012).

The agro-ecological region which Mafinga district falls under is Region III, (Ministry of Lands and Natural Resources, 2017). The average amount of rainfall that Mafinga district receives every year is over 1000 mm. The dominant types of soils in the region are Acrisols, Fluvisols, Leptosols, Lixisols, Association and Vertisols, (Ministry of Lands and Natural Resources, 2017). *Fig 3* shows the soil types found in Mafinga district of Muchinga province

The soil types in Mafinga district are categorized into six major types as shown below namely Acrisols, Association, Fluvisols, Leptosols, Lixisols and Vertisols.

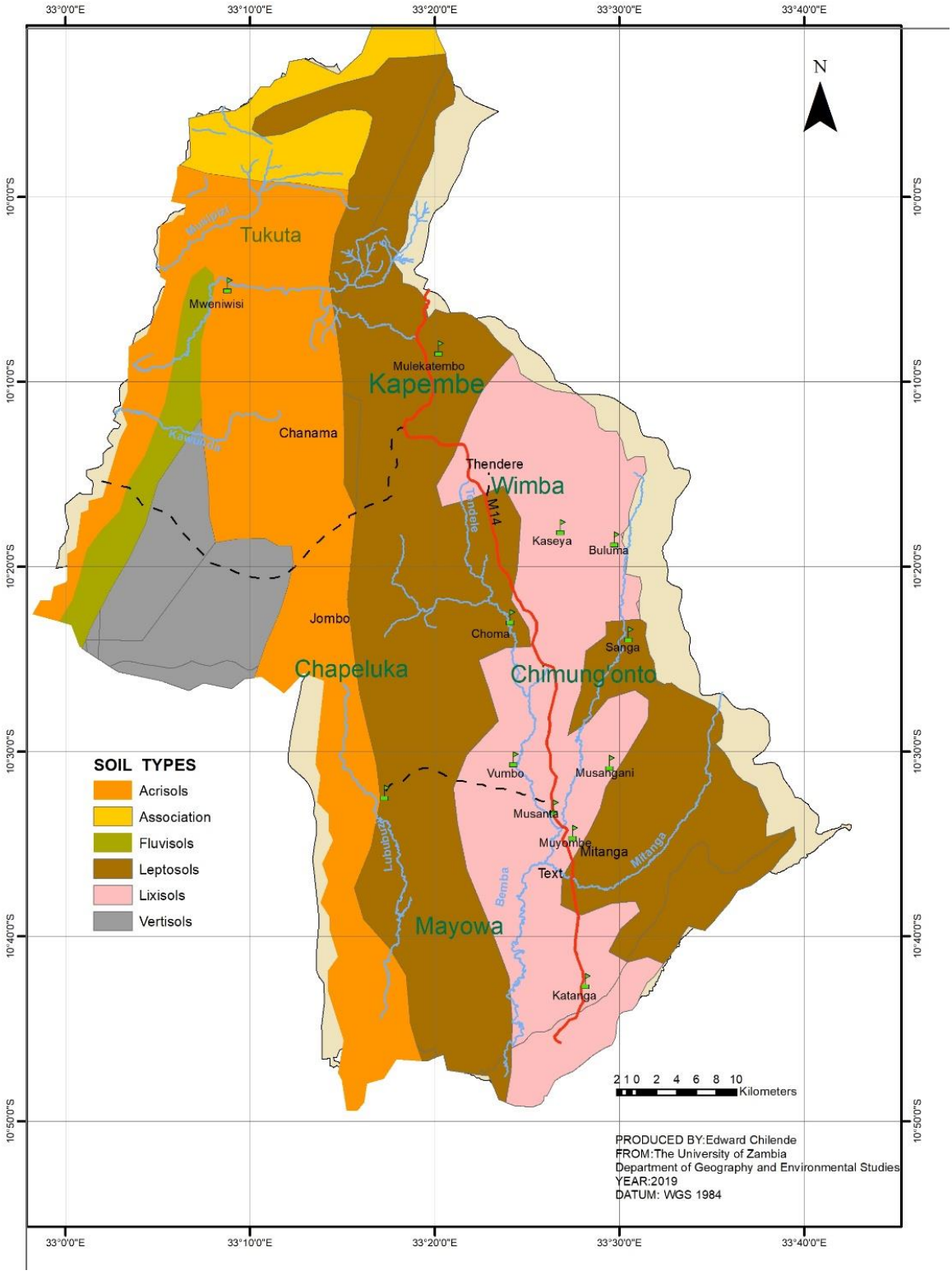

Figure 3: Soil types in the study area

Source: Ministry of Lands and Natural Resources, Surveying Department.

CHAPTER FOUR: RESEARCH METHODS

4.1 Research Design

A case study research design was used in this study. The case of this study was Mafinga district as the study examined the region in a detailed manner as an entity. This study was a qualitative study in approach.

4.2 Sampling Frame

Mafinga district has a total of 255 gazetted villages. The sampling frame in this research was from all the 255 gazetted villages in the study area. The population in the district is estimated to be is about 65,969 (Central Statistical Office, 2010).

4.3 Sample Size

The sample size of the research was 144. This sample size of 144 was determined to be appropriate based on the principle of Blumberg et al (2014) which indicates that the sample size of research is determined by the size of the population in the study area. If the population is big, large sample size is required but if the population is small, only a small sample size is required. In this study, only 9, 475 people are living in 24 villages surrounding 6 forests which were being investigated. From this sample size, 72 were men and 72 were women. The sample size was decided by sampling 24 respondents from 4 villages surrounding each forest food hotspot area. A total of 4 villages were purposively selected based on their relative location to the forest. This implies that one village was randomly sampled from the northern, southern, eastern and western parts of the forest. From each village sampled, 3 were men and 3 were women making the total of 6 respondents per village and 24 respondents per forest food area. Muyombe chiefdom had a total of 3 forest food hotspots area thereby having a sample size of 72. Mwenechifungwe chiefdom had 2 forest food hotspots and it had a sample size of 48 while Mwenewisi chiefdom had only a sample size of 24 because it only had 1 forest food hotspot area.

4.4 Sampling techniques

The study area was divided into clusters of 3 chiefdoms. With the help of traditional leadership, villages near forests, forest reserves and woodlands with forest foods were purposively selected in every cluster. The villages surrounding the forests were grouped in four zones relative to their

location (east, west, north and south) to ensure spatial representation. From the four zones in each forest, only 1 village was selected using simple random sampling. Purposive sampling was used to select 3 men and 3 women in the villages who did PGIS and Participatory Mapping and participated in the Transect walks. Adult men and women between the ages of 18 and 60 years were purposively sampled to do Participatory Mapping and Transect Walk for purposes of mapping the extent of the areas with forest foods. The threshold of 18 years and above was arrived at, since Frances and Salisu (2003:24) contend that "people aged 18 and above play an important role in holding and using information about forest foods".

Only adult men and women who have lived in the village for 10 years and above were purposively selected because they have sufficient knowledge about the forest, forest reserves or woodlands. Besides that, these people know the types of forest foods found in the area and where they are located within the area because they have lived in the area for many years.

4.5 Sources of Data

Primary and secondary data were used in this study. Primary data were collected from Focus Group Discussion and Transect walks. Dale (1995) describes a Transect walk as a group exercise that entails walking between two or more points to intentionally cross or transect a community to explore environmental or social resources. Instruments that were used to collect primary data were interview guides, Global Positioning System (GPS), voice recorder and camera. Secondary data were collected using Topographic Maps and Landsat satellite imagery from USGS. A GPS collected coordinates that were later loaded on a Landsat satellite image on QGIS and later digitized on ArcMap to ascertain the actual forest food hotspots.

CHAPTER FIVE: RESULTS AND DISCUSSIONS

5.1 Identification of plant based and non - plant based forest foods.

The study showed that Mafinga district is blessed with abundant forest food resources. The results of the study show that Mafinga district has 48 types of forest food resources. These 48 forest foods in Mafinga district were identified through Focus Group Discussion. After the identification of forest foods, a transect walk with key informants was done to observe them individually. The 48 types of forest food resources that are available in the region were grouped into 6 major categories. The grouping of forest foods was done according to Frances and Salisu (2003) where each forest food was grouped according to how it is used. The 6 major categories of forest foods found in Mafinga district are fruits, vegetables, honey, insects, mushrooms, roots and tubers. These results correlate with Hari (2013) who argues that the common forest foods that are found in forests are wild fruits, wild leaves which are vegetables, insects, mushrooms, roots and tubers and honey. However, some of the forest foods that Lita and Eric (2012) point out as some of the forest foods such as blackberry, elderberry, huckleberry, lingonberry, Oregon grape and wild plum are not available in Mafinga district.

5.1.1 Fruits

The study showed that Mafinga district has a total number of 33 fruits. The types of fruits that are found in Mafinga district include Masuku (*Uapaca Kirkiana*), Matobo (*azanza garckeana*, *Goron Tula*), Mfungo (*anisophyllea boehmii*), Mposia/Mbula (*parinari curatelliofolia*), Ntumbuzia, Mavilu/Vingundangulube/Mangulungulu, Ntumbukalulu, Casovu, Kafisiamino, Nsongwa,Muvondongo, Munyenjele, Mugwigwi, Mufubu, Tumilwa, Mulebe (*ximenia americana*), Viyenga, Mfisa, Mangulungulu, Bungano, Nsugwa, Musukumpinini, Ntungulu, Magolong'ondo, Mampangwa, Mukolofumo (*diospyros mespiliformis*), Muntunya, Mankolong'onzo, Mantopa, Chombwa, Sululambo, Tunamukonda and Tupipi. *Fig 4* shows some of the fruits that are found in Mafinga district.

Masuku

Masuku

Mampangwa

Viyenga

Figure 4: Fruits in Mafinga District
Source: Field data, 2019.

However, the results of the study show that various fruits were found in various hotspot areas of the Mafinga district. Table 1 summarizes the types of fruits found in Mafinga district, chiefdoms where they are located and their hotspot area.

Table 1: Types and location of fruits in Mafinga district.

CHIEFDOM	HOTSPOT AREA	LOCAL NAME	SCIENTIFIC NAME
Muyombe	**Chimung'onto**	Masuku	*Uapaca Kirkiana*
		Matobo	Azanza Garckeana / Gorona Tula
		Mfungo	*Anisophyllea boehmii*
		Tunamukonda	
		Tupipi.	
		Muntunya,	
		Mankolong'onzo	
		Mantopa	
		Sululambo	
		Mukolofumo	*Diospyros mespiliformis*
	Mayowa	Mposia/Mbula	*Parinari curatelliofolia*
		Masuku	*Uapaca Kirkiana*
		Tunamukonda	
		Ntumbuzia	
		Mavilu	
		Mangulungulu	
		Ntumbukalulu	
		Casovu	
	Chikoya	Muntunya	
		Mankolong'onzo	
		Mantopa	
		Sululambo,	
		Tunamukonda	

		Tupipi.	
		Masuku	*Uapaca Kirkiana*
		Matobo	*Azanza Garckeana / Goron Tula*
		Mfungo	*anisophyllea boehmii*
Mwenewisi	**Tukuta**	Casovu	
		Muvondongo	
		Matobo	Azanza Garckeana / Gorona Tula
		Vigundangulube	
		Kafisiamino	
		Nsongwa	
		munyenjele	
Mwenechifungwe	**Wimba**	Mugwigwi	
		Mufubu,	
		Tumilwa	
		Mulebe	*Ximenia americana*
		Viyenga	
		Mfisa	
		Mangulungulu	
		Bungano	
		Mampangwa	
		Masuku	Uapaca Kirkiana
		Matobo	Azanza garckeana / Gorona Tula
	Kapembe	Mfungo	Anisophyllea boehmii
		Tupipi	
		Tumilwa	
		Ntungulu	
		Musukumpinini	
		Nsungwa	
		Magolong’ondo	
		Mulebe	*Ximenia americana*

The study also reviewed that some of the forest food resources in Mafinga district suffer from deforestation as a result of the traditional farming method known as Chitemene System. The results of this study are similar to what Frances and Salisu (2003) found in their study where most of the trees that produce forest foods in northern Nigeria were cleared during preparation of agricultural land at the onset of the farming season. Frances and Salisu (2003) state that most of the forest food resources in the northern region of Nigeria were cut down and burnt by farmers who wanted a large area for agriculture due to population increase in the region. The findings of the study were also similar to the findings of Arnold et al (2011) who also found that most of the forest food resources in many regions of the world are diminishing from time to time due to increased deforestation at the expense of farming. The results of Arnold et al (2011) showed that most of the forest food resources in many regions of the world are lost due to traditional farming systems that demand the cutting down of trees. This study also showed that Chitemene system is commonly practiced in Mafinga district by the local people. During Chitemene System of farming, trees are cut down on a piece of land where local people want to grow crops such as maize, millet or beans. After trees have been cut down, they are heaped and then burned to ash to increase soil fertility of that particular piece of land. It was found that during Chitemene system of farming, many trees that produce forest foods are cut down and burned to ash which leads to the reduction of forest foods resources in the region. The study further found that some of the trees that are cut down and burned during Chitemene system of farming in Mafinga district are cut down with forest foods such as fruits on their branches. *Fig 5* shows how trees with fruits were cut down and burnt in Kapembe village of Chief Mwenechifungwe in Mafinga district during land preparation of Chitemene System of farming.

Figure 5: Burnt fruit trees

Source: Field data, 2019.

5.1.2. Vegetables

The study further revealed that Mafinga District also has wild vegetables that are consumed by local people. The research revealed that 9 types of vegetables are found in the region. The types of vegetables that are found in the region include Luntwe, Pupwe, Muzaza, Nyunzu, Ikobwa, Chinyenje, Chisokono, Sambwe and Inzembwa. The study showed that these vegetables play an important role to the local community in Mafinga district as they are used as a relish with their staple food which is Nshima. This is in line with Frances and Salisu (2003) whose study shows that 50% of the vegetables that are consumed in northern Nigerian households comes from the

forests in the region. However, it should be noted that there is a minor difference in the findings of this study with the findings of Frances and Salisu (2003) in that some of the plants that produce vegetables in Nigerian forests also produce other forest foods such as fruits or nuts. Contrary to the findings of Frances and Salisu (2011) where they found that some plants that produce leaves, also produce edible fruits. This study found that plants that produce edible leaves as vegetables never produce any other edible forest food resource. All the plants that produce vegetables do not produce other forest food resources in Mafinga district.

5.1.3. Honey

The study also revealed that honey, which is locally known as *buci* is also found in Mafinga district. Due to the availability of tall and huge trees, bees produce honey which the local people go to collect in the bush. The study found that honey plays an important socio-economic role in Mafinga district as local people sell it to neigbouring areas such as Isoka and Hewe in Malawi. One of the respondent in Tukuta village of Chief Mwenewisi stated that he was able to send his son to school at Muyombe Boarding Secondary School after selling honey in Isoka. He stated that he was selling about 20 litres of honey in a month which enabled him to save money for his son who was at a Boarding School. Interviewee 1 in a Focus Group Discussion in Tukuta village explained that he could not have managed to send his son to a Boarding School had it not been for honey that he was selling in Isoka. This clearly shows that honey plays an important socio-economic role in Mafinga district as local people sell it to meet their basic needs. *Fig 6* shows a tree where bees produce honey in Tukuta Forest Reserve in Mwenewisi Chiefdom of Mafinga district.

Figure 6: A tree where bees produce honey

Source: Field data, 2019

However, it should be known that local people in Mafinga District tame bees for honey production. After collecting honey from a tree, the local people have a culture of cutting a log of a tree where they harvested that honey and cover a swarm of bees to produce honey again. When a swarm of bees is covered with a log of a tree, it does not vacate that place and local people produce more honey after some months. The study showed that the tamed bees can produce honey for many years unless they are provoked by something such as humans, wild fire, wild animals or snakes. The findings of this study are contrary to the results of Hari (2013) who found out that all the

honey that was collected by local people was produced by bees in the bush. From his study, Hari (2013) never found local people taming bees in any region. Contrary to the results of Hari (2013), this study found that local people in Mafinga district collect honey from bees that are not tamed in the bush as well as from the bees that are tamed. *Fig 7* shows a log of a tree with tamed bees.

Figure 7: Tamed bees in a log of a tree in Tukuta Forest Reserve of Chief Mwenewisi

Source: Field data, 2019

5.1.4. Insects

The study found that insects are also found in Mafinga district. The results of the study show that the common types of insects that are found in the region are caterpillars which are locally known as *Mabungu*. The study shows that *Mabungu* (Caterpillars) are collected by local people, dried and later prepared as relish. Apart from local consumption as a relish, the study showed that caterpillars are also sold by local people to meet their socio-economic needs. Respondent 4 in a Focus Group Discussion in Chimung'onto village of Chief Muyombe stated that local people usually sell *mabungu* to nearby towns such as Isoka, Lundazi and Nakonde. The respondent further stated that they sometimes export mabungu to a nearby countries such as malawi and Tanzania and have money to meet their daily socio-economic needs. The results of this study are similar to the results of Hari (2013) who found that insects also play an important socio-economic role are they are sold by local people after collection. Hari (2013) clearly states that in his study, about 32 % of the monthly income in the rainy season is derived from insect collection. Hari (2013) gives an example of a community in America where insects play a pivotal role in enhancing the socio-economic status of the community. However, the difference which is there between this study and Hari (2013) is that this study only found one type of insect called caterpillars which are locally known as *Mabungu*. This study found only one type of insect to be available in the entire Mafinga district. Contrary to this study, the study which was done by Hari (2013) found many types of insects that are collected by local people in Africa and the other parts of the world such as in America.

5.1.5 Mushroom

The other forest food that is found in Mafinga district is mushroom which is locally known as *bowa*. The study found that mushrooms are also found in Mafinga district due to heavy rainfall that is experienced in the region during the rainy season. However, the research showed that there are two types of mushrooms namely *bowa* and *mpapamula*. Respondents 2 in Wimba village indicated that mushroom is in two categories namely *bowa* and *mpapamula*. The respondents further explained that *bowa* are those big mushrooms that are usually whitish in colour while *mpapamula* are small mushrooms which are usually yellowish and brownish in colour. Respondent 5 from chapeluka village also stressed that *bowa* is the name given to big mushrooms while *mpapamula* is the name given to small mushrooms available in the region. However, the study found that some of the mushrooms are poisonous if not well cooked. Respondent 6 in Tukuta village narrated that one of his sons got poisoned by the mushrooms that he collected from Tukuta

forest reserve when he was herding cattle. The respondent further narrated that his son was poisoned because his mother never cooked the mushrooms for a long period of time as his son was hungry. Respondent 6 stressed that there is a need to cook the mushroom very well and for a long period of time to avoid being poisoned by the food after eating it.

5.1.6 Roots and tubers

The study found that Mafinga district also has roots and tubers as forest foods that are found in the region. The research identified 2 types of roots and tubers in the region. These two types of roots and tubers that were identified are *cikanda (vinaka)* and *inumbu*. The study found that cikanda (vinaka) is being collected by the local people mainly for sell while inumbu is mainly collected for home consumption. Respondent 3 in Wimba village of chief Mwenechifungwe narrated that the community is lucky in that cikanda (cinaka) which is gradually diminishing in the country is available in the district. However, the research found that inumbu has side effects if taken in excess. It was found that if inumbu is taken in excess, someone might experience stomach pains, vomiting and constipation. This is similar to the findings of Frances and Salisu (2003) whose study found that some of the roots that are found in northern Nigeria have side effects. Frances and Salisu (2013) gave an example of the root of *Young Hyphaene Thebaica plant* which causes severe stomach pains and constipation is taken in excess.

The findings of the study are in line with the permaculture theory in the sense that the forest food resources found in Mafinga district grow in seven recognized layers. Among the seven recognized layers, tall trees that produce fruits such as Mfungo are in the category of the canopy layer while understory is those trees that produce fruits such as Mavilu just under the canopy layer. The findings further showed that the shrub layer in the region is vegetables such as Pupwe and Ikobwa which are dwarf and dry up at a particular period of the year. It was also found that the groundcover layer which is among the seven recognized layers in the permaculture theory is also found in Mafinga district which comprises of mushrooms which are commonly known as bowa by the local people. The study also revealed that the Rhizosphere layer which comprises plants that grow within the soil is also found in the region. Examples of plants that grow in the Rhizosphere layer in Mafinga district include roots and tubers such as chikanda and inumbu. The vertical layer of plants is also found in Mafinga district. Examples of vertical layer plants are pupwe and chisokono which are plants that climb nearby tall plants during their growth. However, there is a need to care for these seven recognized layers as stressed by the permaculture theory to promote balance in the

ecosystem. If care is shown as stated by the permaculture theory, the forest food resources in Mafinga district will be preserved and there will be fare share as they will never go extinct in the region. This will enable the future generation to see the forest foods as well.

5.1.7 Summary of types of forest food resources in Mafinga

The study revealed that Mafinga has about 48 types of forest food resources which are categorised into 6 major groups. These 6 major groups are fruits, vegetables, mushrooms, honey, insects, roots and tubers. The study further revealed that there are about 33 types of fruits in the region, 9 types of vegetables, 2 types of mushrooms, 2 types of roots and tubers , insects and honey which is locally known as buci. In terms of percentage representation, *Fig 8* clearly shows the percentage availability of each type of forest food in the region.

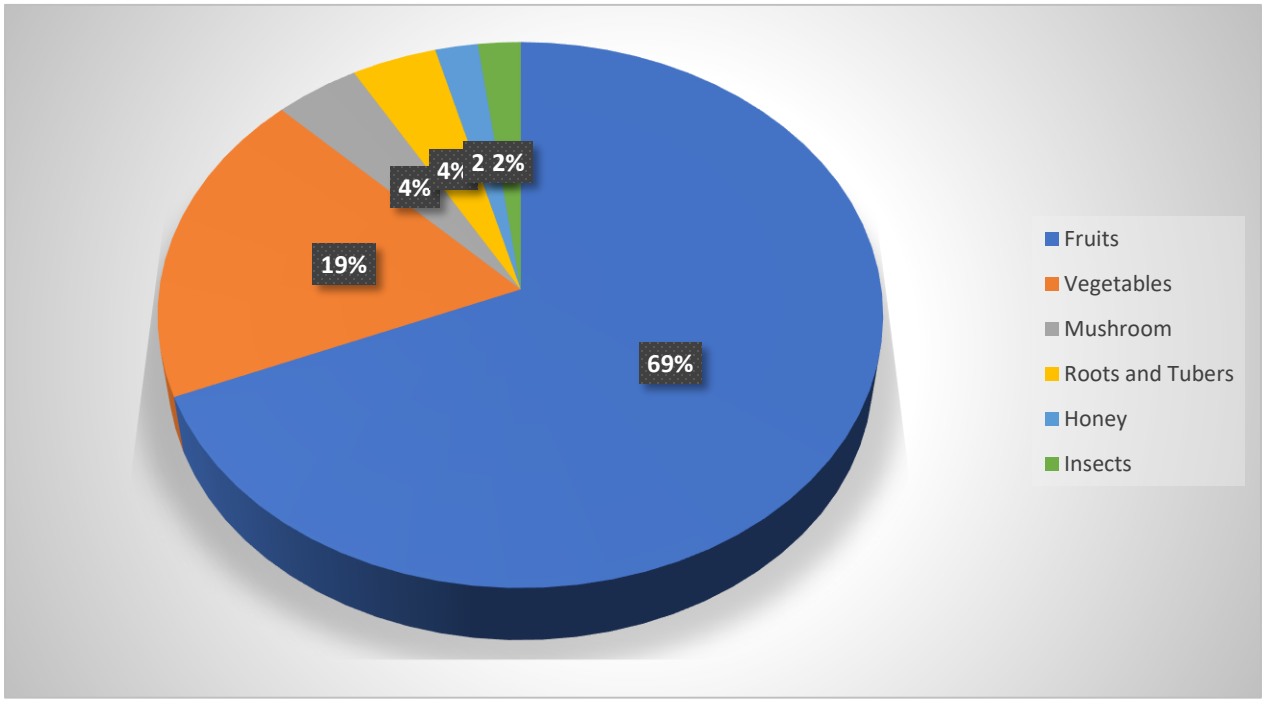

Figure 8: Percentage representation of forest foods in Mafinga district

Source: Field data, 2019.

5.2 Seasonality of forest foods in Mafinga district.

The study categorized the seasonal availability of forest foods into 5 categories. The categorization of forest foods was done according to Frances and Salisu (2003) who grouped forest foods in their

study into 5 categories namely rainy season, off-rainy season, harvesting season and pre-rainy season. However, the category of the pre-rainy season in Frances and Salisu (2003) was renamed in this study to dry-rainy season. This category was renamed because some of the forest food resources are available at the end of the dry season and at the beginning of the rainy season hence using the category dry-rainy season. It should also be noted that the category of harvesting seasonal in Frances and Salisu (2003) was in this study renamed to rainy-dry season. This category was renamed because Frances and Salisu (2003) restricted this period only to the time when people collect their food crops from the fields of which the harvesting period in Zambia is very short. Harvesting season only takes about 2 months of which some of the forest foods are available earlier than those months and go beyond the harvesting period hence using the rainy-dry season to broaden the length of the season. In addition to these seasons, there are forest foods that are available throughout the year making it the fifth category of seasonal availability of forest foods. Similarly to Frances and Salisu (2003), this study found that some of the forest foods in Mafinga district are available in the rainy and off rainy seasons. The research further revealed that some forest foods are available at the end of the rainy season and early dry season. The study also found that other forest foods in Mafinga district are available at the end of the dry season and early rainy season. Furthermore, the results of this study showed that some forest foods in the region are available through out the year. According to the study, the major categories of the seasons in which forest food resources are available in Mafinga district are rainy season, off rainy or dry season, rainy-dry season, dry-rainy season and throughout the year.

5.2.1 Rain season

The results of the study show that 24 types of forest food resources are available during the rainy season. Forest food resources available during the rainy season are available between November and April the following year. Among 24 forest foods found in the rainy season, 20 are fruits, 2 are mushrooms, the other ones are caterpillars and tubers. The names of fruits found in rainy season in the region are *masuku, mfungo, casovu, nsongwa, munyenje, mugwigwi, mufubu, mulebe, mfisa, nsugwa, musukumpinini, sululambo, ntungulu, tupipi, mampangwa, muntunya, mankolong'onzo, tunamukonda, chombwa* and *mantopa.* The names of mushrooms found in the rain season in Mafinga district are *bowa* (big mushrooms) and *mpapamula* (small mushrooms). Caterpillars that are found in the region are locally known as *mabungu* and tubers that are found during the rainy season are *inumbu*. The results of this study are similar to the results of Arnold et al (2011) who found that more 70% of the forest foods found in the rainy season are fruits. This study also found

that 83% of forest foods that are available during the rainy season are fruits. *Fig 9* shows the percentage presentation of types of forest foods which are found in Mafinga district during the rainy season.

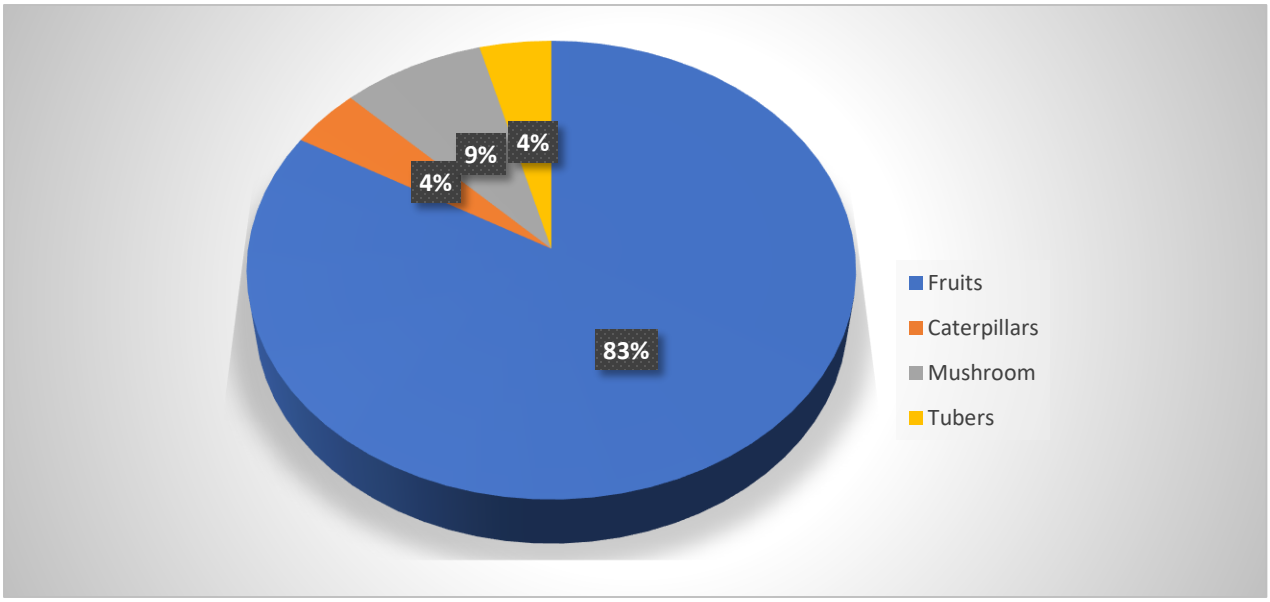

Figure 9: Forest foods available during rainy season in the area

Source: Field data, 2019.

5.2.2 Off rain season

The results of this study also showed that some forest foods in Mafinga district are available in the dry season. The results show that 13 forest foods are available in the dry season. These forest foods available in the dry season are available between May and October. The results showed that among the 13 forest foods available in the dry season, 9 of them are fruits, 3 of them are vegetables and one of them is roots. The names of fruits that are available in dry season in Mafinga district are *matobo, ntumbukalulu, kafisiamino, viyenga, bungano, magolong'ondo, mukolofumo, mposia/mbula* and *mangulungulu.* The names of vegetables that are found in the dry season in Mafinga district are *lunte, chinyenje* and *sambwe.* The roots that are available in the dry season in the region are *cikanda (vinakha).* One of the respondents during a Focus Group Discussion in Wimba village stressed that the region in blessed with *cikanda* despite the root having gone extinct in some regions of the country. He further stressed that *cikanda* plays an important socio-economic

role in the district as many residents deliver it to Isoka district to sell it and meet basic socio-economic needs in their homes. Another respondent from Chapeluka village indicated that she has managed to send her children to school after selling cikanda in Lundazi district. This clearly shows that cikanda plays an important socio-economic role in the district as local people sell it to meet their daily needs. The results of this study are different from the results of Mary and Nigel (1996) in the sense that the highest percentage of forest foods that were found to be available in the dry season were roots. Mary and Nigel (1996) indicate that about 63% of forest foods available in the dry season were roots and tubers. Contrary to that, the results of this study show that most of forest food resources available during the dry season are fruits which constitute 69% while roots and tubers have the lowest percentage constituting 8%. *Fig 10* shows the types of forest foods available in the dry season in Mafinga district.

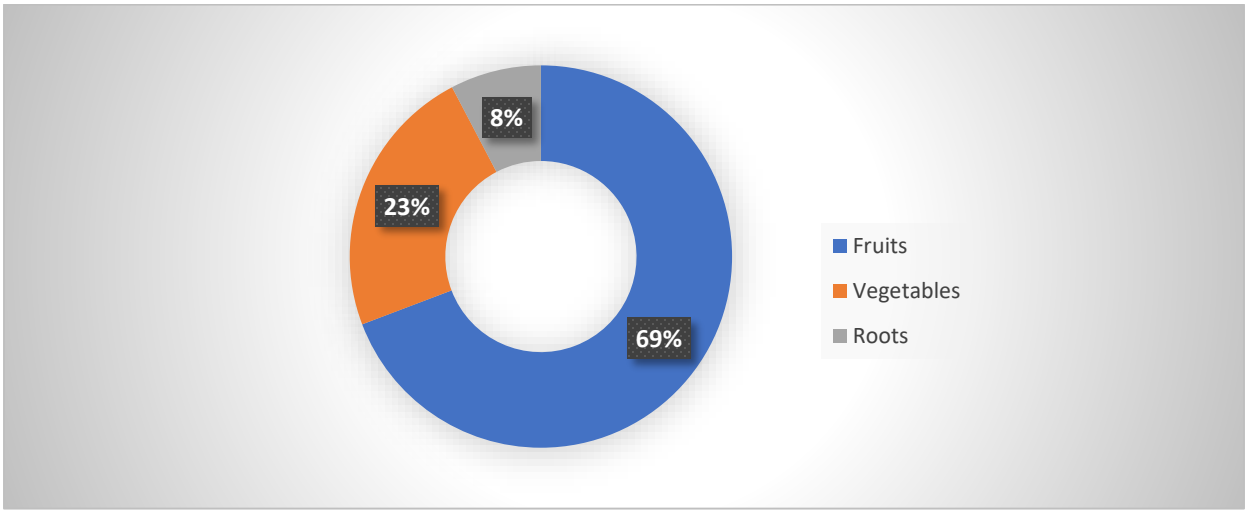

Figure 10: Forest foods available during dry season in the area

Source: Field data, 2019.

5.2.3 Throughout the year

The results of this study also showed that some forest foods in Mafinga district are available throughout the year. According to the results, 7 types of forest foods are available throughout the year. From the 7 forest foods that are available throughout the year, six of them are vegetables while one of them is honey (buci). The six types of vegetables that are available throughout the year are *pupwe (zumba), muzaza, nyunzu, ikobwa, cisokono* and *inzembwa*. Beside these

vegetables, the study showed that honey is also available in Mafinga district throughout the year. Honey also plays an important economic role in Mafinga district as local people sell it to meet their basic necessities in their homes. One of the respondents from Tukuta village of chief Mwenewisi stated that honey helped him very much in 2017 as he did not have enough farm produce as his wife was sick during rainy season. He stated that through selling of honey, he managed to buy food for his family throughout the year. Another respondent from Chimung'onto village in Chief Muyombe stated that she managed to send her child to Muyombe Boarding Secondary school after selling honey in Hewe Township in Malawi. This clearly indicates that honey plays an important role in enhancing the economy of the people in Mafinga district as residents sell honey to meet their necessities in their homes. The results of this study are similar to the results of Frances and Salisu (2003) who found that some of the forest foods in their study were also available throughout the year. However, Frances and Salisu (2003) stressed that despite forest foods being available throughout the year, the number of those forest foods is very small compared to the number of those available in other seasons. Similar to the findings of Frances and Salisu (2003) who found that only 17% of forest foods in Northern Nigeria are available throughout the year, this study also found that only a small number of forest foods in Mafinga district are available throughout the year in the region. The study found that only 14% of forest foods found in Mafinga district are available throughout the year in the region.

5.2.4 Rainy-Dry season

One thing that should be noted is that the study also found that some forest food resources in Mafinga district are available at the end of the rainy season and early of the dry season. The study showed that some forest foods start to be available at the end of rainy reason and also at the beginning of the dry season. These forest foods are available from March to June. The study showed that the only category of forest food resources that is found in the rainy-dry season is fruits. The 3 types of fruits that are available at the end of the rainy season and early dry season are Ntumbuzia, Muvondondongo and Mavilu. Frances and Salisu (2003) also highlight that there are some forest food resources in forests that are available in a transitional season from the rainy season to dry season which ranges from March to June. Frances and Salisu (2003) stress that these forest foods are available at the end of the rainy season and they continue to be available up to the early days of the dry season. This was found to be the case in Mafinga district as some fruits were ready for human consumption towards the end of the rainy season and would continue to be available in the forests even in the early days of the dry season.

5.2.5 Dry-Rain season

The study also revealed that some forest foods in Mafinga district are available towards the end of the dry season and early rainy season. These forest foods are available from September to December. The study found that only one type of forest food is found towards the end of the dry season up to the early rainy season. The study showed that Tumilwa which is a fruit is the only forest food which is available during the dry-rainy season. Arnold et al (2011) also indicate that some of the forest foods in their study were also available in the dry-rainy season. The only difference between the results of Arnold et al (2011) and the results of this study is that Arnold et al (2011) found that most of the forest foods that were found in the dry-rainy season were roots and tubers while the results of the study show that the forest foods that are found during this season are fruits.

It has to be noted that the study revealed that most forest foods in Mafinga district are available during the rainy season while the smallest number of forest foods is available in the dry-rainy season. The availability of more forest foods in the rainy season correlates with Lita and Eric (2013) who stresses that most of the forest foods in Zambia are available in the rainy season due to the abundance of moisture which favors the growth of most forest foods in a conducive environment. Lita and Eric (2013) put it clear that most forest foods are available in the rainy season because the wet soils enable many forest foods such as fruits and mushrooms to grow well and get ready for human consumption. The results of this study also match with Simulyamana (2017) who contends that forest foods find it hard to be available during the off-rainy season as they dry up due to lack of water. Fig 11 summarizes the seasons in which forest food resources are available in Mafinga district of Muchinga province and the number of forest foods available in every season. Table 2 shows a summary of the seasonal availability of forest food resources that are available in Mafinga district.

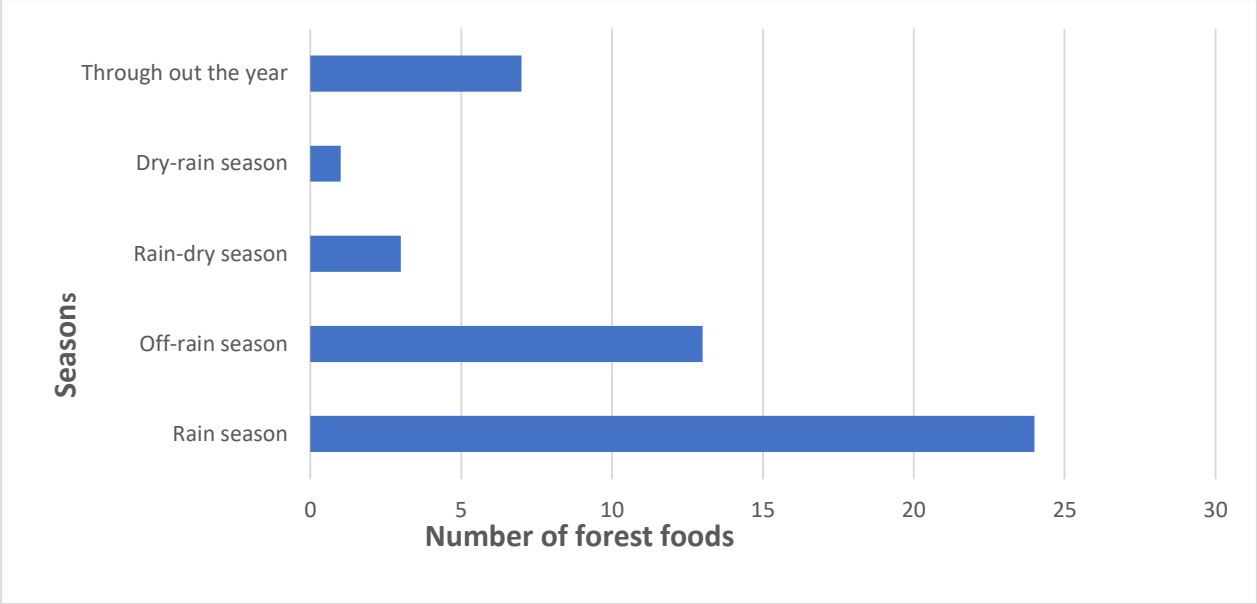

Figure 11: Summary of seasonal availability of forest foods in Mafinga district

Source: Field data, 2019.

Table 2: Summary of seasonal availability of forest foods resources in Mafinga district

Rainy season		**Off-rainy season**		**Rainy-dry season**		**Dry-rainy season**		**Throughout the year**	
Fruits	20	Fruits	9	Fruits	3	Fruits	1	vegetables	6
mushroom	2	vegetables	3					Honey	1
caterpillars	1	Roots & tubers	1						
Roots/tubers	1								
Total	24	Total	13	Total	3	Total	1	Total	7

Source: Field Data, 2019.

5.3 Spatial distribution of forest foods in Mafinga District using Participatory GIS (PGIS).

To analyze data of the spatial distribution of forest foods in Mafinga district, a Landsat image was downloaded from USGS Earth Explorer Satellite. The date of acquisition of the satellite image was 1st June, 2018.The Path of the image is 169 and the row is 67. The satellite image was used in

this study to facilitate the digitization of GPS Coordinates on QGIS 3.2.1 version. The image was later loaded with GPS coordinates that were collected during a transect walk and later digitized the coverage area on QGIS 3.2.1 version. In the first phase, the GPS coordinates were loaded on QGIS. In the second phase, the areas which were covered with coordinates were digitized as coverage areas of forest foods and the last phase was done to digitize individual forest foods found in every forest food hotspot area using ArcMap 10.3 version. Fig 12 shows the stages of data analysis on QGIS 3.2.1 version.

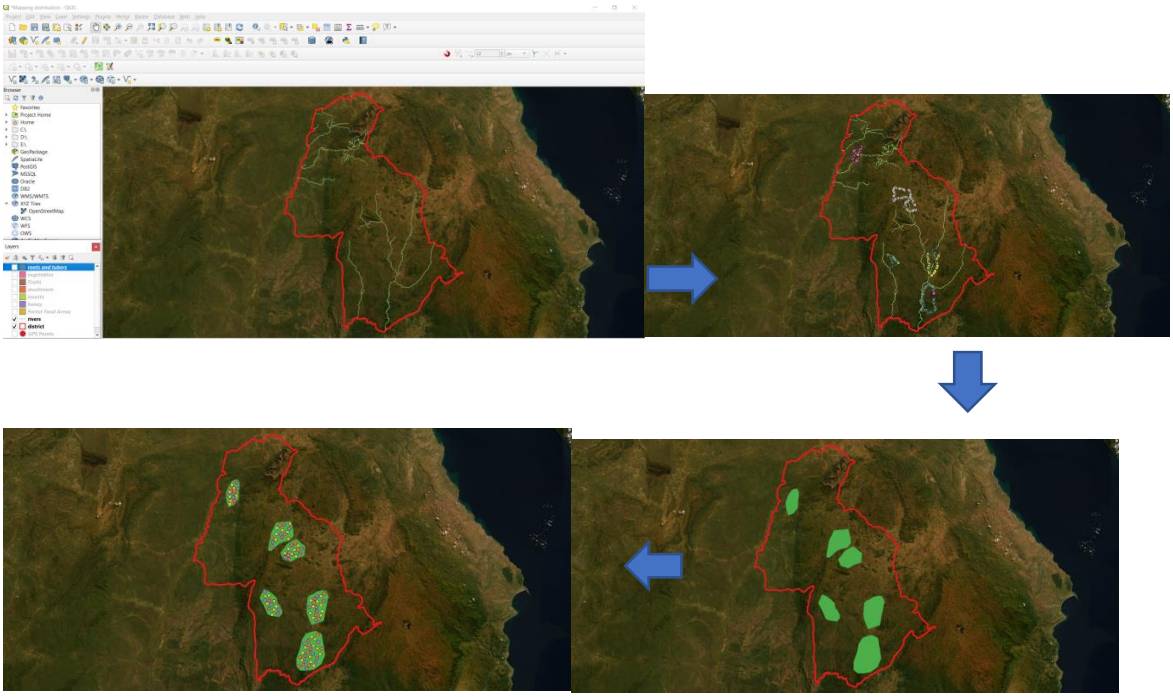

Figure 12: Landsat image of Mafinga district

Source: USGS Earth Explorer Satellite: 2018

5.3.1 National Parks and National Forest Reserves distribution in the study area.

The results of this study showed that Mafinga district has National Forests Reserves and Game Park Areas. The study found that Mayowa and Tukuta forest food areas are found in the gazetted National Forest Reserves. Therefore, the local authority should consider legalizing the collection of forest foods by the local people so that local people can freely collect forest foods from those gazetted national forest reserves to enhance food security. Nevertheless, the study found that there are no forest foods that are collected in Nyika National Park which is located in the southern part

of Mafinga district. Fig 13 shows the National Forests Reserves and Game Management Areas found in Mafinga district.

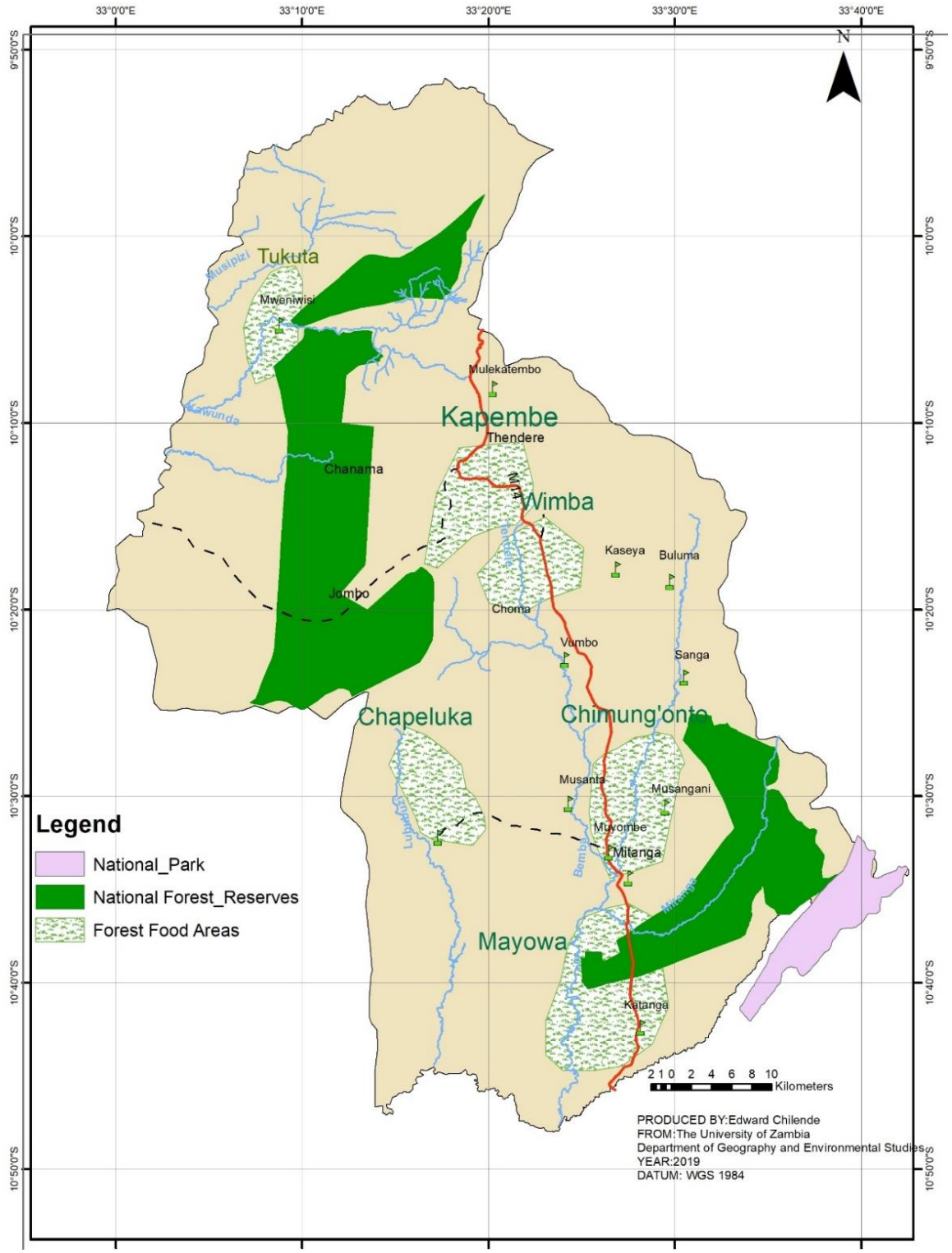

Figure 13: National Parks and National Forest Reserves in Mafinga District

Source: Ministry of Lands and Natural Resources, Surveying Department.

5.3.2 Forest food hotspot areas.

Most parts of Mafinga district have forest food resources. However, the study found that the hotspot areas of forest food resources in Mafinga district are Chimung'onto forest reserve, Mayowa watershed, Chapeluka forest reserve, Wimba woodlands, Kapembe forest and Tukuta forest reserve. It is worth noting that Chimung'onto forest reserve, Mayowa watershed and Chapeluka forest reserve are located in Muyombe chiefdom while Wimba woodlands and Kapembe forest are in chief Mwenechifungwe while Tukuta forest reserve is in chief Mwenewisi. This indicates that most forest food resources in Mafinga district are available in Muyombe chiefdom, followed by Mwenechifungwe chiefdom and a minimal quantity is found in Mwenewisi chiefdom. *Fig 14* shows the distribution of forest foods across the chiefdomsin Mafinga district.

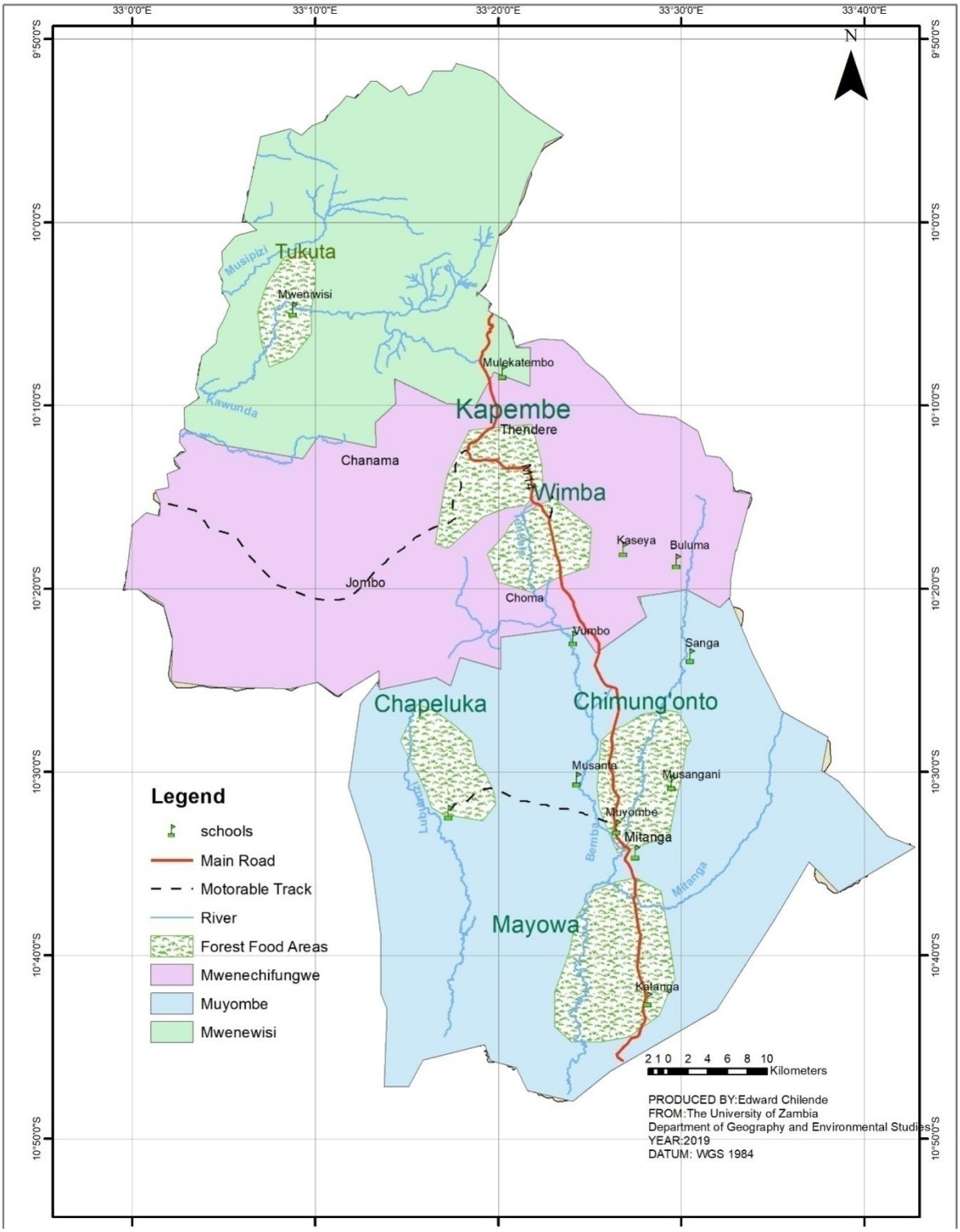

Figure 14: Spatial distribution of forest foods in Mafinga chiefdoms

Source: Ministry of Lands and Natural Resources, Surveying Department

The study found that the soil type that is found in most hotspot areas of forest foods in Mafinga district are Lixisols and Leptosols. The results show that though not every forest food hotspot area is characterised by Lixisols and Leptosols, most of them have these two types of soils as the dominant ones. Rita and Eric (2012) also argue that most of the forest foods in many regions of the world are available in areas characterised by Lixisols because of their mineral components. This implies that the results of Rita and Eric (2012) are similar to the results of this study in that most of the forest foods in Mafinga district are found in areas with Lixisols type of soil. However, this study found that in addition to Lixisols, some of the forest food resources are found in Leptosols which are not found in the study of Rita and Eric (2012). Their study only found one type of soil to be favouring the growth of forest foods while this study found two types of soils namely Lixisols and Leptosols to be favoring the growth of forest foods in Mafinga district. *Fig 15* shows the soil types in forest food hotspot areas in Mafinga district.

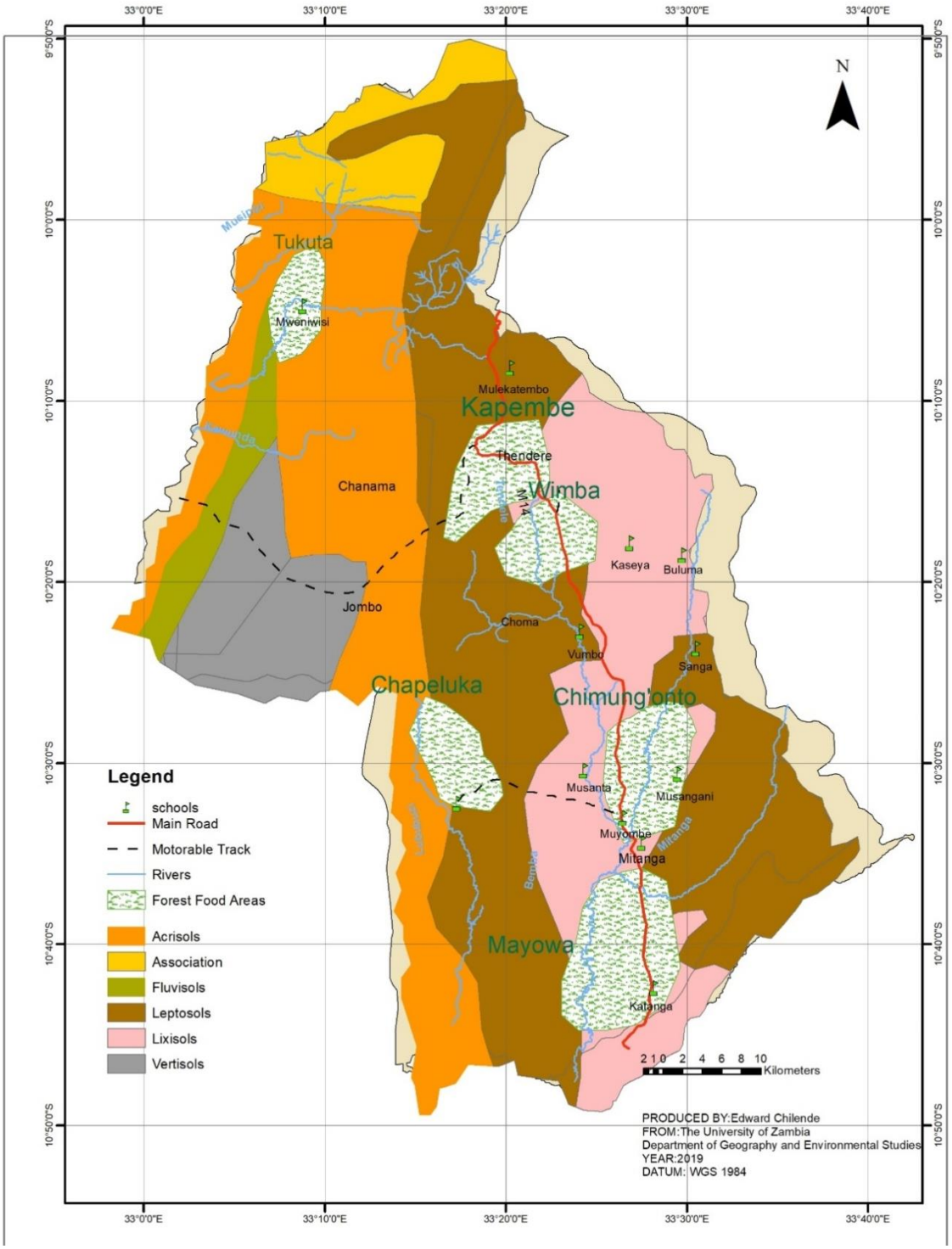

Figure 15: Soil types in forest food areas

Source: Ministry of Lands and Natural Resources, Surveying Department.

The study also found that most of the forest food resources in Mafinga district are found along rivers. The study found that the spatial distribution of forest food resources in Mafinga district is mainly concentrated along the rivers that are found in Mafinga district. This shows that the soil type that is found along the rivers favors the growth of forest food resources.

However, it should be noted that forest food resources are not only found in areas that are far from people's homes. Contrary to what FAO (2016) who argues that most of the forest foods are distributed in quiet areas that are not frequently visited by human beings, this study found that some of the forest foods are distributed in areas that are closer to people's homes. This study found that some of the forest foods are distributed in areas that are very close to residential areas where people do not walk long distances to gather and collect such forest food resources. An example is Wimba Woodlands where the forest food hotspots are very close to the villages and Wimba Primary School where by pupils go out in the forests to collect forest foods during break time when they are at school. *Fig 16* shows how forest food resources are distributed near villages in Mafinga district.

The results of this study correlate with the results of FAO (2013) in that most of the forest foods are distributed in hilly and mountainous areas. FAO (2013) state that most of forest foods are distributed in areas of high elevation such as hills and mountains. Similarly, the results of the study show that most of the forest foods in Mafinga district are located in hilly and mountainous areas.

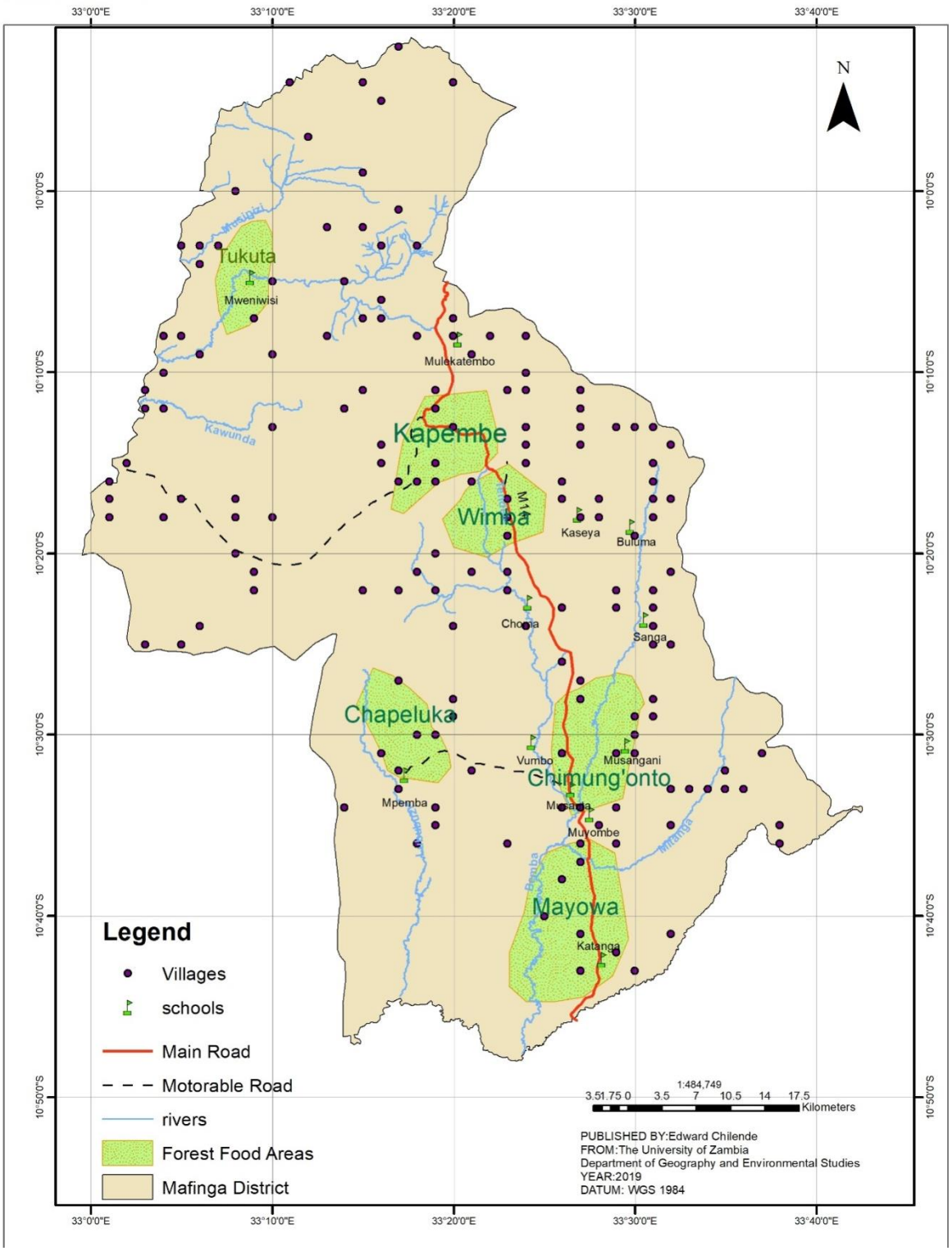

Figure 16*:* Map showing forest foods areas near villages

Source: Field Data, 2019.

Fig 16 shows the areas where forest food resources are found in Mafinga district. However, it should be known that these areas have different forest foods spread across them. The study shows

that forest foods in Mafinga district are not found in specific areas of forests. For example, the northern part of a forest can not only be having fruits only. The northern part of a particular forest can have a variety of forest fruits such as fruits, honey, mushrooms and insects mixed on the same locality. This implies that within the same locality, fruits, mushrooms, roots and tubers can be available unlike a situation where fruits are found in a specific area of the forest, honey and mushrooms are also found on their specific areas. The study further shows that within the same locality of the forest, all the forest foods can be available. This is similar to what Frances and Salisu (2003) found in their study where forest foods were not found on a specific region of the forest. Their study found that within a particular area of the forest, a variety of forest foods ranging from insects, nuts, fruits and roots were found in the same locality the northern part of Nigeria.
However, the study shows that although forest foods are found across the coverage area, they differ in terms of quantity. The study shows that some areas have more forest foods than others on the same forest. For example, fruits were not only found on the eastern part of Mayowa watershed but were found on the entire area of Mayowa watershed only that the Eastern part of the watershed had more fruits than the other parts of the watershed. This is similar to the results of Arnold et al (2011) who found that on the same forest, there was a variation in quantity of forest food resources in their study. Arnold et al (2011) found that some areas of the forests in their study area where having more forest foods than others but on the same forest.

The study also found that the major categories of forest food resources that are found in all the six areas in Mafinga district are fruits, vegetables, insects, mushrooms, honey, roots and tubers. The results of this study are similar to the results of Hari (2013) who found that fruits, vegetables, honey, mushroom, insects, roots and tubers were the available forest foods that were distributed across his study areas. However, fish and eggs from wild birds which were also found to be distributed across his study area were not found to be among the forest foods that were distributed in the study area of this research. This implies that among the forest foods that Hari (2013) found to be distributed in his study area, fish and eggs were missing in the study area of this study. The study also shows that honey is found in Mayowa watershed, Chimung'onto, Wimba, Kapembe and Tukuta and Chapeluka. The study also shows that insects are only found in Chimung'onto and Chapeluka. This indicates that insects (caterpillars) are not available in Mayowa, Wimba, Kapembe and Tukuta. *Fig 17* shows how types of forest foods are spread across Mafinga district.

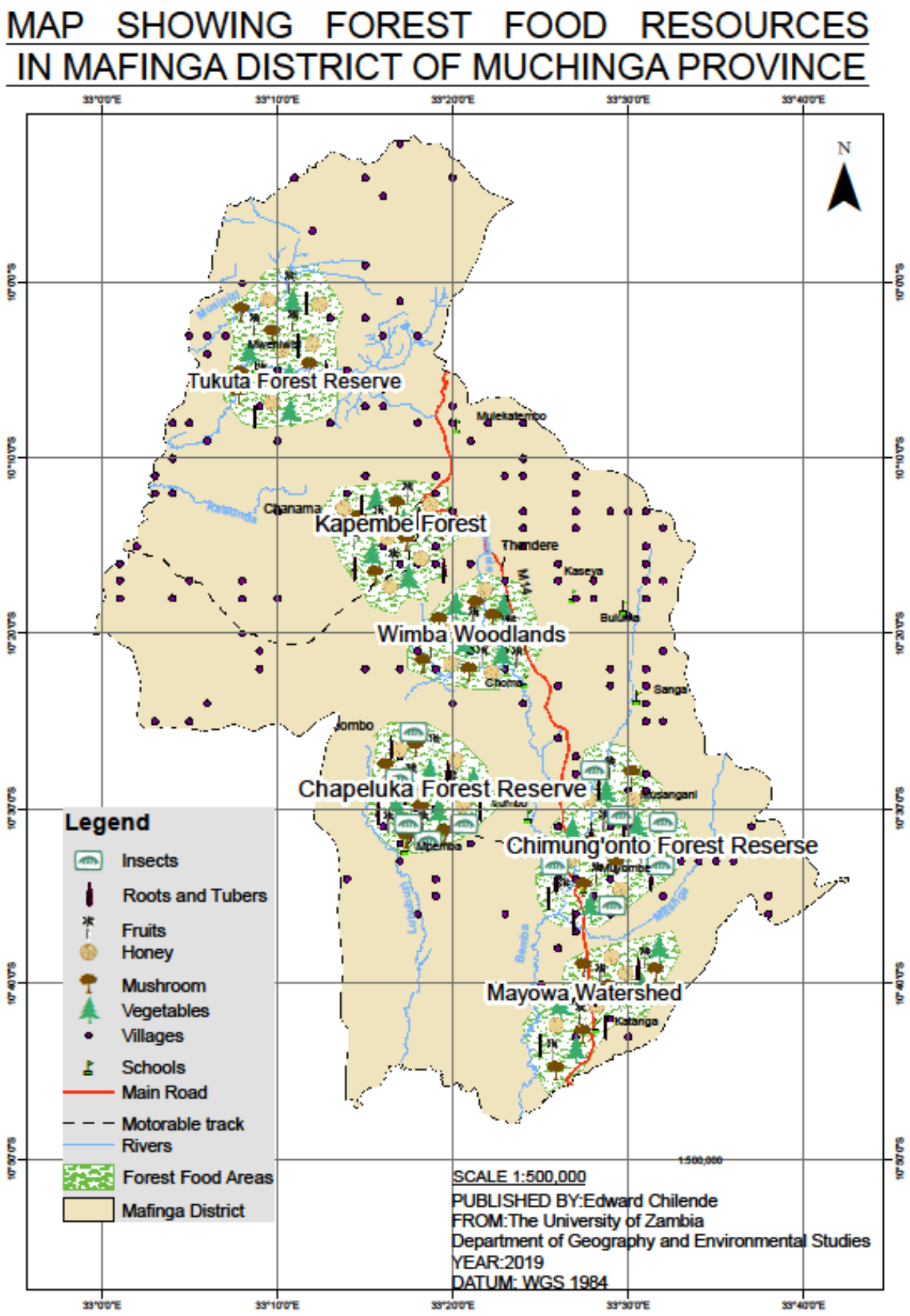

Figure 17: Spatial distribution of types of forest foods in Mafinga district

Source: Field Data, 2019.

Table 3 summarizes the spatial distribution of forest food resources in Mafinga district of Muchinga province.

Table 3: Summary of the coverage area of forest foods in Mafinga district

AREA	**TYPES OF FOREST FOODS AVAILABLE**
Mayowa Watershed	Fruits, vegetables, roots and tubers, mushrooms and honey.
Chimung'onto Forest Reserve	Fruits, vegetables, roots and tubers, mushrooms, honey and insects.
Chapeluka Forest Reserve	Insects, fruits, vegetables, roots and tubers, honey and mushrooms.
Wimba Woodlands	Vegetables, mushrooms, fruits, roots and tubers and honey.
Kapembe Forest	Honey, mushrooms, fruits, vegetables, roots and tubers.
Tukuta Forest Reserve	Fruits, honey, mushrooms, roots and tubers and vegetables.

Source: Field Data, 2019.

5.3.3 STUDY VALIDATION OF THE FOREST FOODS SPATIAL DISTRIBUTION.

Validation of this study was done after a successful map production of forest food hotspots. Map validation was done according to Dale (1995) who states that after the map has been produced for PGIS, a researcher should go back to the experts in the area for ground-truthing and map verification before results are published. Validation was done by printing 6 maps on A2 papers to represent 6 hotspot areas. After maps were printed out, residents in villages surrounding hotspot areas were given the maps to check if the information on the map corresponded to the information on the ground. A Focus Group Discussion was used to interview the residents to check whether the information on the map was correct.

Only one village surrounding forest food hotspots was randomly selected. From each sampled village, 4 men and 4 women were purposively sampled to verify the types of forest food resources available in that particular hotspot area and verify the coverage area. The purposively sampled respondents who conducted the map validation were people who had lived around the forests for more than 10 years. From the six forest food hotspot areas, it was found that the mapping of the

coverage area of forest food resources was correctly done except in one area. The hotspot area that was not correctly mapped in terms of spatial distribution was Chapeluka forest reserve where the local people found that honey was missing in Chapeluka hotspot area. After realizing that honey was missing on the map of forest food hotspots in Chapeluka, QGIS 3.2.1 was used to revise the map as shown on Figure 17 to include honey on the map showing spatial distribution of forest foods in Mafinga district.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study established that Mafinga district has numerous forest food resources. The study showed that the forest food resources found in Mafinga district are fruits, vegetables, roots and tubers, caterpillars, honey and mushrooms. The study further showed that most of the forest food resources found in Mafinga district are fruits which constitute 69 % of the total forest foods in the region, followed by vegetables which constitute 19 % of the available forest foods. The study further showed that mushrooms and roots and tubers constitute 4 % each while insects and honey constitute 2 % each. The study showed that the forest foods available in Mafinga district play an important socio-economic role to the local community as they are sources of food during a famine. They study further showed that besides being sources of food to local people, forest food resources in Mafinga district are a source of income the local community as they are being sold by local people to meet their daily needs.

The study further established that the seasons in which forest food resources are available in Mafinga districts are the rainy season, dry season, rainy-dry season, dry-rainy season and throughout the year. The study showed that most of the forest foods are available during rainy season of the year. The study also established that forest food resources in Mafinga district are available in six major areas namely Chimung'onto forest reserve, Mayowa watershed, Chapeluka forest reserve, Wimba woodlands, Kapembe forest and Tukuta forest reserve. The study showed that most of the forest food resources are found in Muyombe chiefdom which has three hotspot areas namely Chimung'onto forest reserve, Mayowa watershed and Chapeluka forest reserve. The study also showed that Mwenechifungwe chiefdom has two forest food hotspot areas namely Wimba woodlands and Kapembe forest while Mwenewisi chiefdom has only one hotspot area of forest food resources known as Tukuta forest reserve.

6.2 Recommendations

Based on the findings of the study, the following recommendations were made:

i. The six types of forest food resources found in Mafinga district should be conserved and protected by the local authority to enhance food security and economic stability in the region.
ii. The local authority should allow in coming of investors to add value to the forest food resources that are found in Mafinga district so that local people are employed and the value of local forest food resources is added.
iii. The government should establish industries that will process forest food resources in Mafinga district to promote the value addition of local forest foods and enhance employment creation.
iv. The areas that are distributed with forest food resources in the region should not be sacrificed for any developmental project. Construction of any school, hospital or any other infrastructure should not be done on hotspot areas of forest foods.
v. The government should promote the use of Participatory Geographic Information System (PGIS) in Community Based Forest Management (CBFM) because it uses indigenous knowledge to ascertain the types of forest foods or other natural resources available in the region and their actual geographical location.
vi. The government should purchase modern devices such as Geographic Position System (GPS), computers and many other devices used in GIS to promote the use of PGIS in Community Based Forest Management to mitigate the effects of climate change.
vii. The government should train more scholars in the field of Participatory Geographic Information System (PGIS) to enhance forest food preservation in the country as a way of mitigating climate change in the country.
viii. Small and Medium Enterprises (SMEs) should process, preserve and market forest foods as a way of adding value and creating employment for the local people.
ix. The Forestry Department and the scientific community should encourage people to cultivate forest foods bearing plants so that they are conserved and multiplied for commercial processing.

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APPENDICES

APPENDIX I

STRUCTURED INTERVIEW GUIDE

SECTION A: PERSONAL INFORMATION

A. What is your name: ……..……
B. Sex: male ( ) female ( )
C. How old are you? below 40 years ( ) between 40 and 60 ( ) above 60 ( )
D. From which kingdom do you come from? Muyombe ( ) mwiniwisi ( ) mwenechifungwe ()
E. Which village do you stay? …….

SECTION B: FOREST RELATED INFORMATION

A. Are there forests near your home? Yes ( ) No ( )
B. If the answer to the above question is yes, what is the name of the forest? ……
C. What plant-based forest foods are found in the forest near your home?
   tubers ( ) roots ( ) Fruits ( )
   Others(specify):……
   ……..……
   …….
D. Mention the above named plant-based forest foods found in the nearby forest:
   ……
   ……
   ……
   ……
   …….
E. What none plant based forest foods are found in the forest near your home?

Insects ( ) honey ( ) Catapillars ( ) Game meat ( ) fish ( )

Others (specify)……..……

……

……

F. Mention the above named non-plant based forest foods in the forest near you:……

……

……

……

……

……

……

G. Which season of the years are the above-mentioned forest foods available in the region?

Dry season ( ) rainy season ( ) Others (specify) ……..

Thank you very much for your co-operation.

APPENDIX II

SEMI-TRUCTURED INTERVIEW GUIDE

My name is Edward Chilende. Iam a student at the University of Zambia doing a research in titled "Mapping of forest foods in Mafinga district using Participatory GIS (PGIS). You have been selected to be interviewed in this research. The response given will be treated with confidentiality.

BACKGROUND INFORMATION

A. Size of the Focus Group Discussion: …….
B. Males: ( ) Females: ( )
C. Age of respondent:

……
……..

D. Name of the chiefdom: ……
E. Name of the village: ……
F. Name of the nearest forest: …….

LOCATION INFORMATION

1. For how long have you been living in this village?
   ……
   ……
   ……
2. Are there plant-based forest foods in the forest near you? ……
3. If the answer to the above question is yes, what types of plant-based forest foods are in the forest near your home?
   ……
   ……
   ……
   ……
   ……

……

……

4. Are there none plant-based forest foods in the forest near you? ……
5. If the answer to the above question is yes, what types of none plant-based forest foods are in the forest near your home?

   ……

   ……

   ……

   ……

   ……

   ……

   ……

   Co-ordinates of the forest in the village (coverage):

   ……

   ……

   ……

   ……

   ……

   ……

   ……

   ……

   ……..

6. What seasons of the year are the forest foods mentioned in question (3) and (5) available in the forest near you?

   ……

   ……

   ……

   ……

   Thank you for your co-operation.