The role of edible weeds as food amidst an herbicide revolution in Zambia

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Affidavit

I, Alysha Vehre, give my solemn word that I have compiled this work solely and without external help, have not utilized any sources outside those permitted and that the sources used have been given verbatim or quoted textually in the places indicated.

Thesis Topic: The role of edible weeds amidst and herbicide revolution in Zambia

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In addition to the printed version, a copy of this work was also submitted in electronic format to the appropriate examiners.

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Abstract

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Concern continues to grow for global food security as rates of hunger and malnutrition are on the rise. African leafy vegetables and wild edible plants have been well-documented as important contributors to diets amid times of scarcity, however little attention has been given to these plants in the context of agricultural weeds. This distinction is important as herbicides are on the rise across developing nations and it is important to assess the trade-offs that come with them. The aim of this study was to assess the importance of edible weeds for food security and how they are affected by growing rates of herbicide adoption. Research was conducted in the Eastern and Southern Provinces of Zambia. Quantitative interviews were conducted with 159 households along with field walks to collect data on the types of weeds consumed, household consumption patterns and herbicide adoption rates. The relevance of edible weeds for food is evident, especially during periods of heightened food insecurity. They are however, more than famine foods. Edible weeds were consumed regardless of socio-economic characteristics indicating their importance in food culture. Moreover, edible weeds were often used additionally for fodder, medicine and nutrition. Herbicide usage was low, however, households demonstrated a high interest in adoption. While no correlation was found between herbicides and edible weed consumption, this will likely change in the future as herbicide adoption rates are expected to increase. Further promotion and training in agrochemicals should take into account the associated risk to edible weeds as a pertinent food group to smallholder farmers.

Summary

Introduction/Background

Concern continues to grow for global food security as rates of hunger and malnutrition are on the rise. African leafy vegetables and wild edible plants have been well-documented as important contributors to diets amid times of scarcity, however little attention has been given to these plants in the context of agricultural weeds. This distinction is important as herbicides are on the rise across developing nations. Herbicide usage may provide benefits to increasing food security by increasing yields, however they may also come with unintended consequences to human and environmental health. Furthermore, they may adversely affect the contribution of edible weeds as a food source. As herbicide use is expected to continue grow, it is important to assess the trade-offs that come with them.

Objectives/Research Questions

The objective of the study was to provide an understanding of if, and how edible weeds contribute to household food security for small-holder farmers in Zambia and, in relation to edible weeds, how herbicide usage may, in turn, affect food security. In order to meet the objective, the following research questions were used:

1. Which edible weeds are used by smallholder farming households?
2. How relevant are edible weds for household food security?
3. What are the trends in herbicide adoption amongst smallholder farmers?
4. How are these trends affecting edible weed consumption?

Methods

The study was conducted in the Eastern and Southern Provinces of Zambia. Quantitative interviews were conducted with 159 randomly selected households. The head of the household along with the person responsible for food were interviewed on the topics of household demographics, farm description, pesticide usage, edible weed usage, food security and knowledge and perception of herbicides, nutrition and edible weeds. In addition to interviews, 14 guided field walks were carried out in order to collect and identify the edible weeds described in the interviews.

Results

Edible weeds were consumed by all of the households within the study. A total of 22 edible weeds were identified (2 to their genera and 20 to their species). The most prominent weeds used by households include *Amarathus* sp., *Cochorus olitorius*, *Bidens* sp., *Ceratotheca triloba* and *Cleome gynandra*. Edible weeds were seldom used only for food and were used additionally as fodder by 81% of households, medicine by 46% of households and income by 11% of households. Households consumed edible weeds regardless of socio-economic factors (age, gender, income and education) but were consumed significantly more frequently by households in the Southern Province than in the Eastern Province ($r=-0.4$, $p=<0.001$).

Edible weeds were consumed primarily as a means to supplement their diets (54%, n=157) but were also almost equally consumed out of tradition (53%) and preference (46%). Edible weeds were preserved by 137 households, from which 99% did so to ensure food security for the future. The peak times for edible weed collection also coincide the with periods of times in which households expressed being food insecure. Furthermore 87% of total number of respondents (n=270) perceived edible weeds to be especially important during times of food scarcity.

Herbicides were used by 34% of households primarily as a means to effectively manage weeds and to save labor. Edible weeds were still collected from sprayed fields. Moreover, the times of peak herbicide application overlap with the times in which edible weeds are the most frequently collected by households. However, no correlation between herbicide usage and edible weed consumption was discovered.

Over half of the respondents began using herbicides within a two year prior to the study (since 2017) and 91% had started within the previous 5 years (since 2014). Over 60% of households described wanting to adopt herbicides or adopt more herbicides. The primary constraint in adoption was due to financial reasons followed by a lack of knowledge. 24% of respondents described being unsure if herbicides are potentially harmful or not (n=270). Although 89% of respondents believed it was necessary to wear protection when using herbicides, safety procedures were not well followed.

Discussion

The study illustrates the importance of edible weeds as food, especially in times of heightened for insecurity. Many of the edible weeds identified are well-known across Africa as traditional leafy vegetables. Higher consumption rates in the Southern Province than in the Eastern Province may be indicative of cultural or climatic differences relating to food security. Consumption patterns as well as the overlapping timeframe of peak edible weed consumption and peak food insecurity demonstrate the importance of edible weeds for food security. The high nutritional content of edible weeds makes them especially important for nutrition, dietary ailments and as fodder. Edible weeds are, however, more than famine foods.

Herbicide adoption rates are low, but higher than anticipated. The benefits of herbicides may result in reduced labor equating to reduced cost and more time. However, the loss of work opportunities arising from reduced labor may also widen inequality and increased food insecurity for some. Additionally, the benefits of herbicide usage are dependent on proper implementation. The lack of regulation of herbicide products, and the limited knowledgeability of farmers on safety and application procedures reveal major problems for future herbicide usage. Although no correlation was found between herbicides and edible weeds, application patterns and growing adoption rates of herbicides indicate that this will likely change in the future.

Conclusion

The relevance of edible weeds in the diets of Zambians is evident, especially during periods of heightened food insecurity. Moreover, edible weeds are often used additionally for fodder, medicine and nutrition. While no correlation was found between herbicides and edible weed consumption, trends indicate that this will likely change in the future with higher adoption rates of herbicides. Furthermore, current regulations and training for farmers in pesticide use is inadequate and, if left as is, will likely result in a number of environmental and health complications with the cost of edible weeds as a food source. Further promotion and training in agrochemicals should take into account the associated risk to edible weeds as a pertinent food source to smallholder farmers.

Thematic Link to the Foundation fiat panis

Concomitant with the objectives and ideals of the Foundation fiat panis, this study shines a light on the usage of edible weeds as a means of food and nutrition security for smallholder farmers in Zambia. Edible weeds have received little attention in literature and in the current efforts for increasing food security in Zambia. While edible weed species have been well-documented across Africa for their roles amidst periods of famine, the lack of acknowledgement as agricultural weeds has put them at risk of disappearing with the introduction of herbicides.

Herbicides are a relatively new technology in Zambia with trends across SSA indicating the likelihood for adoption rates to increase. Increased usage of herbicides brings with it a number of benefits including reduced labor and higher yields. These benefits on one hand offer the potential to increase food security but at the cost of a valuable food source: edible weeds.

The trade-offs analyzed in this study examine the effects of herbicides amongst smallholder farmers in Zambia and the effects on food security in regard to edible weeds. The findings demonstrate that agricultural edible weeds play a significant role in mitigating current food insecurity. Furthermore, herbicides, as implemented by respondents in the study, will not likely provide benefits worth the risk of losing edible weeds as a food source. Increased regulation and training are needed to ensure the quality of herbicide products and the knowledgeability of farmers in order to protect themselves and the environment, as well as to have effective results. Additionally, it is recommended that efforts be made to preserve and protect edible weeds through education and cultivation.

List of Abbreviations

CFU – Conservation Farming Unit

CO – Camp Extension Officer

CPWC – Critical Period for Weed Control

DACO – District Agricultural Coordinator

EUR – euro

FISP – Federal Input Subsidy Program

FRA – Federal Reserve Agency

ha – hectare

HoH – Head of Household

MoA – Ministry of Agriculture

NGO – Non-governmental Organization

PRF – Person Responsible for food

RALS – Rural Agriculture Livelihood Survey

SHoH – Single Headed Household

SSA – Sub-Saharan Africa

ZMW – Zambian Kwacha

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1. Introduction

Over 800 million people around the world suffer from hunger and malnutrition. Rates of food insecurity are especially high in sub-Saharan Africa (FAO et al., 2017). Zambia exemplifies this case with 37% of its population estimated to be experiencing hunger (Chapoto et al., 2018). In Zambia, hunger and malnutrition go hand-in-hand. However, policies implemented for improving food security are mainly directed at maize production and increasing agrochemical usage (FAO, 2018; Mwanamwenge & Harris, 2017). 89% of households in Zambia grow maize, which accounts for over 50% of cultivated land (Chapoto & Zulu-Mbata, 2016). As a result, diets are heavily reliant on maize with only small proportions of more nutrient-rich foods like legumes, fruits, vegetables and meat. Nearly half of the population experiences seasonal hunger (Mwanamwenge & Harris, 2017). Moreover, food inaccessibility and lack of dietary diversity have resulted in 40% of children suffering from stunted growth and various health consequences resulting from nutrient deficiencies (Mwanamwenge & Harris, 2017). The most notable deficiencies are micronutrient deficiencies such as Vitamin A, B_{12}, Folate, Iron and Iodine (Chapoto et al., 2018; FAO, 2009).

As a way to combat malnutrition, edible weeds have been widely used across the globe to supplement diets (Cruz-Garcia & Price, 2012). Weeds are generally considered to be undesirable plants from the human perspective (Maroyi, 2013). In the scope of agriculture, these plants can compete with desired crops for resources resulting in lower yields and hinder harvesting or other management tasks (Randall, 2017; Oerke, 2006). The concern about weed management prompted the rapid expansion of chemical treatments (i.e., herbicides) in the early - mid 1900's to replace the labor-intensive practice of manual weeding (Timmons, 2005). However, in many developing areas, such as sub-Saharan Africa, the introduction of agrochemicals began just over a decade ago (Haggblade et al., 2017a). These areas have relied predominantly on manual weeding which could be coupled with harvesting edible weeds for consumption. A number of studies have demonstrated that, edible weeds are more than an agricultural foe and are an important source of food, nutrition, medicine, and income, especially in developing countries (Maroyi, 2013; Cruz-Garcia & Price, 2012; Gupta, Srivastava, & Lal, 2017; Hillocks, 1998; Ong & Kim, 2017; Ojelel & Kakudidi, 2015; Badimo et al., 2015). Wild edible plants, like edible weeds, are typically higher in micronutrients and bioactive secondary metabolites than their cultivated counterparts, making them important contributors to nutrient deficit diets (Bacchetta, et al., 2016). In addition, the added biodiversity from weeds can make them important for erosion control, supplying organic matter and minerals to soil and even aide in pest suppression (Maroyi, 2013; Hillocks, 1998).

Yet, despite the relevance of edible weeds, there is a growing trend in developing nations to transition to using agrochemicals. This is a result from the desire to achieve higher yields of staple crops and the growing interest in conservation tillage (Mwanamwenge & Harris, 2017; Sheahan & Barrett, 2017). Land use change as a result of agriculture commercialization is one of the major threats to edible weed usage (Bharucha & Pretty, 2010). In Africa, agrochemicals, like herbicides were once inaccessible due to high costs and poor infrastructure. The introduction of off-patent agrochemicals by Asian suppliers has increased availability and cut down costs leading to higher adoption rates (Haggblade et al., 2017a). This trend is especially visible in Ethiopia, which has seen herbicide usage triple in the past decade (Seneshaw et al., 2017).

As agrochemical usage is expected to grow throughout Africa, it is important to understand how alternative food sources like edible weeds are affected and what this effect will have on the current status of food and nutrition security in Zambia, especially for subsistence farmers. Against this background, the proposed research aims to investigate how the use of herbicides affects the supply of edible weeds, which can grow on the fields, on fallow land and on the edges of fields.

2. Research aims

2.1. Research problem

While wild edible plants have long been acknowledged as important contributors to food baskets in developing countries, the importance of these plants as agricultural weeds has been vastly overlooked. Herbicides are being introduced in Zambia with the intent to aid in agricultural productivity, and thereby also aid in food security. When introducing a new technology, it is important to understand all of the potential consequences in doing so. One unintended consequence could be the eradication of a valuable food source, namely edible weeds. The aim of this project is to explore the relevance of edible weeds for household food security in the Eastern and Southern Province of Zambia and how the current trend of agrochemical adoption may affect their usage as well as the livelihoods of farmers who rely on them.

2.2. Research questions and objectives

The objective of the study was to provide an understanding of if and how edible weeds contribute to household food security for small-holder farmers in Zambia and, in relation to edible weeds, how herbicide usage may, in turn, affect food security.

The following research questions were used to in order to meet the study's objectives:

1) <u>Which edible weeds are used by smallholder farming households?</u>

    - What edible weed species are eaten by households and where are they collected from?
    - How many different species of edible weeds do households consume and which are the most important?
    - Are edible weeds used for purposes other than food, and if so, which ones are the most important?

2) <u>How relevant are edible weeds for household food security?</u>

    - When are edible weeds consumed and how frequently are they consumed during these periods of time?
    - Why are edible weeds consumed and how are they perceived amongst households?
    - Are edible weed consumption patterns affected by household food security?

3) <u>What are the trends in herbicide adoption amongst smallholder farmers?</u>

    - How many households are using herbicides and how long have they been using them?
    - How interested are households in herbicides?
    - Why do household use herbicides and how are they applied?

4) <u>How are these trends affecting edible weed consumption?</u>

- When and where are herbicides applied?
- Does the application of and/or interest in herbicides affect household consumption of edible weeds?

3. State of the art

3.1. Edible weeds

3.1.1. Defining edible weeds

Edible weeds, as a source of food, are undervalued as the term 'weed' typically evokes a negative connotation (Rapoport et al., 1995; Turner et al., 2011). Weeds are commonly defined as any plant that is growing where it is unwanted and, in regard to agriculture, where they can also interfere with the growth of desired cultivated plants (Turner et al., 2011). As such, the advancement of agricultural practices has focused greatly on the eradication of these plants with little regard to their importance as a possible source of food (Gianessi, 2013). In the context of this study, the term 'edible weed' is used to describe self-seeding leafy plants that grow in, or around agricultural fields without human intent (Mascorro-de Loera et al., 2019; Maroyi, 2013). As opposed to the aforementioned definition of weeds described by Turner (2001), here, edible weeds are not defined by unwantedness as it is believed that, despite their spontaneous growth, they are potentially wanted or liked amongst certain populations (Ong & Kim, 2017).

Edible weed species have been examined in many studies under the umbrella terms, "African Leafy Vegetables", "Traditional Vegetables", "Indigenous Vegetables", etc. (Maseko et al., 2018; Nyaruwata, 2019; Vorster et al., 2007; Chivenge et al., 2015). These terms, however, represent a broad collective of cultivated lesser-known vegetables as well as, wild edible plants that are gathered from both wild and anthropogenic ecosystems. While a number of the edible plants that were documented within these studies are described as 'weedy plants' that are collected from cultivated and fallow fields, very few studies have focused on their importance as agricultural weeds. Specifically, *Amaranthus* sp., *Cleome gynandra* and *Bidens pilosa* are edible plants that have been mentioned across studies in Sub-Saharan Africa that are also known arable weeds (Nyaruwata, 2019; Mavengahama et al., 2013; Vernon, 1983).

The consumption of edible weeds can be explained in part by the “botanical dietary paradox”. Through deforestation, wild collection sites are pushed further away from villages. In turn, communities that are reliant upon wild foods, tend to collect from areas that are more accessible (Cruz-Garcia & Price, 2011). Rather than traveling to wild habitats, agricultural fields may act as reliable, time saving and less burdensome collection sites for farmers, especially if it can be paired with the task of hand weeding. Furthermore, in Mexico and Zimbabwe, farmers were found to be selective in their weeding process, leaving edible weeds to grow amongst the main crop (Madamombe-Maduna et al., 2008).

3.1.2. Edible weeds and their uses

As a way to combat hunger and malnutrition, wild edible plants, including edible weeds, have been used around the globe to supplement diets (Cruz-Garcia & Price, 2011; Nyaruwata, 2019; Addis et al., 2005; Madamombe-Maduna et al., 2008). These plants may play an especially important role for food insecure regions as rates of global food insecurity continue to rise leaving over 820 million people without adequate access to food and nutrition. Sub-Saharan Africa is one of the areas most affected by food insecurity in which over half of the population experiences moderate to severe food insecurity (FAO et al., 2020; Kabisa et al., 2019).

Sub-Saharan Africa is composed, in large part, of semi-arid climates that are heavily prone to drought (Chivenge et al., 2015). The effects of climate change have increased both the intensity and frequency or extreme weather events, such as drought and flooding (Ayanlade et al., 2018; Kotir, 2011). These erratic weather patterns have created additional challenges for small holder farmers who rely on rain-fed farming systems (Kotir, 2011). Even without climate challenges, many households experience seasonal hunger. Seasonal hunger occurs as result of dwindling supplies from the previous year’s harvest while the crops of the current farming season are not yet ready for harvest (Vaitla et al., 2009; Mwanamwenge & Harris, 2017).

The collection of edible weeds may help to contribute to the diets of those facing food scarcity. Maroyi (2013) found that in Zimbabwe edible weeds were used as a “survival strategy”. Edible weeds not only played an important role in the daily diets of households but were also preserved to be used for future food security (Maroyi, 2013). In Thailand, edible weeds were discovered to be important for food and nutrition security amongst rice farmers

(Cruz-Garcia & Price, 2011). The reliability of edible weeds in times of food scarcity is partly due to their hardiness and drought tolerance. Weeds, like *Amaranthus* sp., can be found in poor soils and water scarce environments making them likely to still be accessible even when exotic crops, like maize, have failed (Alemayehu et al., 2014; Dzerefos et al., 1995).

Edible weeds are also considered to be high in minerals and nutrients (Rapoport et al., 1995). Food insecurity consists of not only the lack of food, but also the lack of essential nutrients in order to be healthy. Insufficient nutrient uptake has resulted in high occurrences of anemia especially prevalent among women and children (Mofya-Mukuka & Mofu, 2016). Diets in Sub-Saharan Africa are highly reliant on maize with little consumption of more nutrient dense and diverse foods (Fanzo, 2012). Eating edible weeds add dietary diversity and may help to treat and prevent dietary diseases, like anemia (Mofya-Mukuka & Simoloka, 2015; Achigan-Dako, 2014). Edible weeds are used as medicine for more than nutrition-based ailments. *Bidens pilosa* was documented to treat conditions including mouth ulcers, measles and sore throat (Mofya-Mukuka & Simoloka, 2015). Moreover, in West Africa, *Cleome gynandra* was found to be used to treat over 40 different types of diseases including malaria (Sogbhossou, 2017). In developing nations, modern medicine is often not widely accessible, available nor affordable (Sharma et al., 2011; Shewamene et al., 2017). Instead, many still rely on traditional medicines derived from wild plants, including edible weeds (Sharma et al., 2011; Cruz-Garcia & Price, 2012).

Beyond the benefits of human consumption, edible weeds are used for fodder and income. In Thailand, 21% of edible weeds consumed by farming households were additionally used as fodder (Cruz-Garcia &Price, 2012). A study in Mexico found that all of the weeds in maize fields had utility; the most important use being fodder. All of the edible weeds that were consumed by households were additionally used for fodder. Moreover, the weeds used for fodder were sold, generating an income of approximately 55% of the net income the farmers had made from maize (Vieyra-Odilon & Vibrans, 2001). In Zimbabwe, some households sold edible weeds at local markets as a way to supplement their income (Maroyi, 2013).

3.1.3. Edible weeds in agroecosystems

Edible weeds may provide indirect benefits including erosion control, increasing biomass and increasing biodiversity (Mavengaham et al., 2013; Vieyra-Odilon & Vibrans, 2001; Gliessman et al., 1981). Agricultural soils in Sub-Saharan Africa face major challenges with degradation due to erosion, nutrient leaching and the loss of soil organic matter (Masso et al., 2017; Zingore et al., 2015). Weeds can act as a cover crop, preventing soil erosion and trapping nutrients to prevent runoff (Moreau et al., 2020; Weil, 1982). Additionally, the biomass added from the weeds contributes to the soil organic matter, which in turn creates better water retention (Gliessman et al., 1981; Rawls et al., 2003).

The added biodiversity from weed species may also help to conserve genetic resources and aid in pest management. Penagos, et al. (2003) had found that weedy maize fields fared better against the fall army worm (*Spodoptera frugiperda*) than maize fields with strict weed control measures. This was attributed to the added biodiversity and higher numbers of beneficial insects (Penagos et al., 2003). *S. frugiperda* is a major invasive pest that was introduced into Africa within the last five years and is responsible for significant losses of maize (Sisay et al., 2018; Day et al., 2017). The presence of certain weed species could act as hosts to beneficial insects, like parasitoid wasps, that have the potential to be a highly effective, and long-term, control method for *S. frugiperda* (Southon et al., 2019; Blaix et al., 2018).

3.1.4. Threats to edible weeds

Little attention is given to edible weeds in the context of food security, and as a result, they are at risk of disappearing from food baskets along with the knowledge of these plants (Borelli et al., 2020; Keatinge et al., 2015). The transition to more “Western” diets has created access to cheaper processed foods whereas more nutritious foods, like horticultural products, meat and dairy, have become less affordable (FAO et al., 2020; Wenhold & Faber, 2012). While this dietary shift may increase access to calories, it may also increase the nutrition gap by moving diets away from more nutritious traditional foods, like edible weeds (Wenhold & Faber, 2012; Joala et al., 2016). Additionally, edible weeds are primarily collected as wild foods and not often cultivated leaving them vulnerable to overexploitation.

The introduction of herbicides has created a new threat facing the future usage of edible weeds. Edible weeds are weeds, and they are not differentiated by the researchers and extension workers who advocate for their removal from fields (Vorster et al., 2007; Shakleton, 2003). While farmers can be selective during manual weeding, the use of herbicides may entirely eradicate all weeds from the field, including edible weeds (Mavengahama et al., 2013; Joala et al., 2016).

3.2. Herbicides

3.2.1. Weed management and herbicides

Weed management has been around since the start of crop domestication and is used to control weeds during pre- and post-emergence (Swinton & Van Deynze, 2017). Weeds are considered to be one of the biggest threats to crop cultivation, and if left unmanaged, can reduce crop yields significantly and force farmers to abandon their fields (Gianessi & Williams, 2011; Haggblade et al., 2017a).

There are four primary groups of weed control techniques including: Manual, mechanical, flooding and chemical control. Manual weeding is the oldest method used involving the removal of weeds by hand. This process requires a significant amount of labor and time (Haggblade et al., 2017a). Mechanical weeding, with the use hoes or draft animals with plows works by removing, severing and/or bury weeds, comparatively, lessening the burden of labor. However, it was not until the development of tractors that time and labor were able to be significantly reduced. Motorized mechanical weeding allows for faster ground coverage but can be costly in terms of fuel and equipment (Hussain et al., 2018). In order to keep up with varying rates of weed emergence both manual and mechanical weeding require repeated passes (Swinton & Van Deynze, 2017).

Flooding is practiced primarily in the rice-growing cultures in Asia to control early season weeds. The soil is flooded with around 5-10 cm of water which drowns out the majority of weed species (Daramola et al., 2020). This method must also be paired with hand weeding in order to manage the late season weeds (Haggblade et al., 2017a). Similar to mechanical weeding, flooding involves soil disruption. If not managed properly, these weed control methods can lead to soil erosion and degradation (Haggblade et al., 2017a; Lehman et al., 2015; Van Oost, 2000).

Chemical weed control is the removal of weeds with the use of herbicides, also known as "weed killers", which can be paired with herbicide tolerant crops (Haggblade et al., 2017a; Vats, 2015). Herbicides became popularized in the 1950's and 1960's during the "chemical era" post-world war II (Gianessi & Reiniger, 2017; Vats, 2015). The use of chemical agents to control weeds opened up opportunities for reduced labor and minimized soil disturbance. Reduced tillage practices were already underway after over plowed fields resulted in the

“Dust Bowl” during the 1930’s in the United States (Trigo et al., 2020). It wasn’t until the development of herbicides that reduced tillage and zero tillage practices were able to gain momentum (Trigo et al., 2020). Tillage is a form of mechanical weed control. By minimizing tillage, or not using tillage practices at all, weed pressure can become incredibly high, especially in the first few years of transition (Hobbs et al., 2008). The introduction of herbicides provided a means to control weed pressure without soil disturbance.

Herbicides work by binding to proteins and disrupting the protein function (Bhat et al., 2016). The manner in which herbicides work to control weed populations, and the types of plants affected, vary based on the active compounds. Modern herbicides are classified into around 20 different modes of actions or targeted sites of disruption, including photosynthesis pathways, lipid synthesis, and amino acid metabolic pathways (Duke, 2011). Additionally, herbicides can be selective against broad leaf or grassy plants or non-selective affecting a broad-spectrum of plants. The introduction of the non-selective herbicide, glyphosate paired with herbicide resistant crops spawned a global transition of weed management (Swinton & Van Deynze, 2017; Green, 2016).

3.2.2. Herbicide trends

Herbicides comprise nearly half of all pesticide sales world-wide and are applied on over 90% of cropland in the United States, European Union, Japan and Australia (Vats, 2015; Gianessi & Williams, 2011). While interest in herbicides increased rapidly in western countries, developing nations were relatively untouched until around 2005 (Haggblade et al., 2017a). In Africa, herbicides have been used in experimental maize plots since the 1960’s, however the rate of herbicide usage, particularly amongst small holder farmers, has been low (Gianessi, 2013; Gabrowski & Jayne, 2016). The promotion of herbicides grew in Africa around the 1990’s along with the increased interest in reduced tillage as a part of the movement for conservation agriculture (CA) (Gabrowski & Jayne, 2016). Herbicide adoption amongst small holder farmers nevertheless remained relatively unaffected as high costs and limited access to herbicides remained major hinderances (Haggblade et al., 2017a). That is, until around 2010 when cheap off-patent suppliers from Asia developed more affordable herbicides which were able to infiltrate the markets in Sub-Saharan Africa (SSA). The increased accessibility paired with the demand arising from labor shortages and higher wage rates spawned what is being called the “herbicide revolution” for Sub-Saharan Africa (Haggblade et al., 2017a; Tamru et al., 2016).

3.2.3. Potential for herbicides in SSA

The expansion of herbicides in SSA creates an opportunity for increasing yields, reducing labor and cultivating larger areas of land (Gianessi & Williams, 2011). The yield gap between SSA and the rest of the world continues to widen. For cereals, the average production in kg/ha is less than half of the global average (Tian & Yu, 2019). Part of this discrepancy has been attributed to the limited use of herbicides in Africa (Tian & Yu, 2019; Gianessi & Willliams, 2011). Hand weeding and hoeing are labor intensive and difficult to carry out frequently enough to keep up with weed growth during the critical period for weed control (CPWC) (Gianessi, 2013; Knezivic & Datta, 2015; Tamru et al., 2016). The CPWC is the time in which weeds must be removed or else competition with the crops will ultimately result in lower yields and potentially crop failure (Knezivic, 2015). A study conducted in Mali found that farmers who used herbicides spent half as much time weeding as farmers without (Haggblade, 2017b). This time savings can be significant for smallholder farmers who spend around 50-70% of their labor time on hand weeding (Gianessi & Williams, 2011). Reducing the time spent on weed management can open up opportunities for other activities that farmers would normally not have time for including, tending to other farming needs that might otherwise be neglected, education, household and childcare, personal care, as well as other income producing endeavors (Gianessi & Williams, 2011; Sheahan et al., 2017). These benefits could be especially valuable to women, who disproportionately make up a majority of the hand weeding labor, and children who may otherwise be forced to leave school to work in the fields during the peak weed season (Gianessi & Williams, 2011). In addition to time, herbicides can also save money. Herbicide prices have fallen over 50% since 2007 whereas wage rates for laborers have continued to increase. (Haggblade, 2017a).

The expansion of herbicide use, however, comes with a number of concerns. Herbicides are often criticized for their potential deleterious effects on humans and the environment (Hasanuzzaman et al., 2020; Kang et al., 2016). Depending on the class and method of application, herbicides can cause varying degrees of adverse effects on waterbodies, soil health and non-target plants and animals (Hasanuzzaman et al., 2020). A study carried out in China by Qi et al., 2020 found that fallow field biodiversity was negatively affected from even low concentration sprayings of herbicides in neighboring fields. Additionally, herbicide runoff into waterbodies can adversely affect marine life populations, resulting in toxic algae blooms, population loss and bioaccumulation of toxic compounds in marine species which can be hazardous to the humans who consume them (Ojemaye et al., 2020; Adedeji & Okocha, 2012; Hasanussaman et al., 2020). Consumption of contaminated drinking water and foods with pesticide residues are of special concern in rural areas in SSA where the markets are less regulated by quality controls (Hasanuzzaman et al., 2020; Anakwue, 2019).

A higher concern for human health, however, lies with the direct exposure to herbicides. In SSA, the limited access to safety equipment and lack of knowledge of safe application methods and handling procedures puts farmers and others who handle these chemicals (vendors, mixers, transporters, etc.) at risk for a number of short-term and long-term health consequences (Kang et al., 2016). Depending on the level of exposure, herbicides can cause skin and eye irritation, dizziness, diarrhea, cardiovascular and pulmonary illness, and cancer (Anakwue, 2019; Hasanuzzaman et al., 2020).

Another concern for herbicide expansion is the prevalence of fraudulent products and distribution by unqualified individuals (Tamru et al., 2017). The lack of adequate quality control measures and training has led the way for counterfeit, mislabeled and diluted products creating additional environmental and health risks (Goeb, 2013; Haggblade, 2017a; Tamru et al., 2017). One study carried out in West Africa estimated the prevalence of counterfeit herbicides to be close to 35% (MIR Plus, 2012). Contrary to the intended results, the use of poor-quality products and improper implementation can instead result in lower yields or failed crops (Goeb, 2013; Tamru et al, 2017).

4. Methods

4.1. Area of study

The study took place in Zambia, which is a landlocked country in southern Africa. Zambia is a diverse nation with 73 different ethnic groups, comprised of seven language clusters (Central Statistical Office, 2014a). The official language of the country is English, although it is not widely spoken outside of urban areas (Central Statistics Office, 2012).

The Eastern Province of Zambia was selected as a field site based on prior studies finding the use of wild edibles to be important for household consumption in the area (Mofya-Mukuka & Simoloka, 2015). Related observations indicated that some of these plants may be growing as agricultural weeds and also collected from the fields for use. The Southern Province was selected as an additional field site in order to understand if these plants are used in other areas of the country across regional and cultural boundaries.

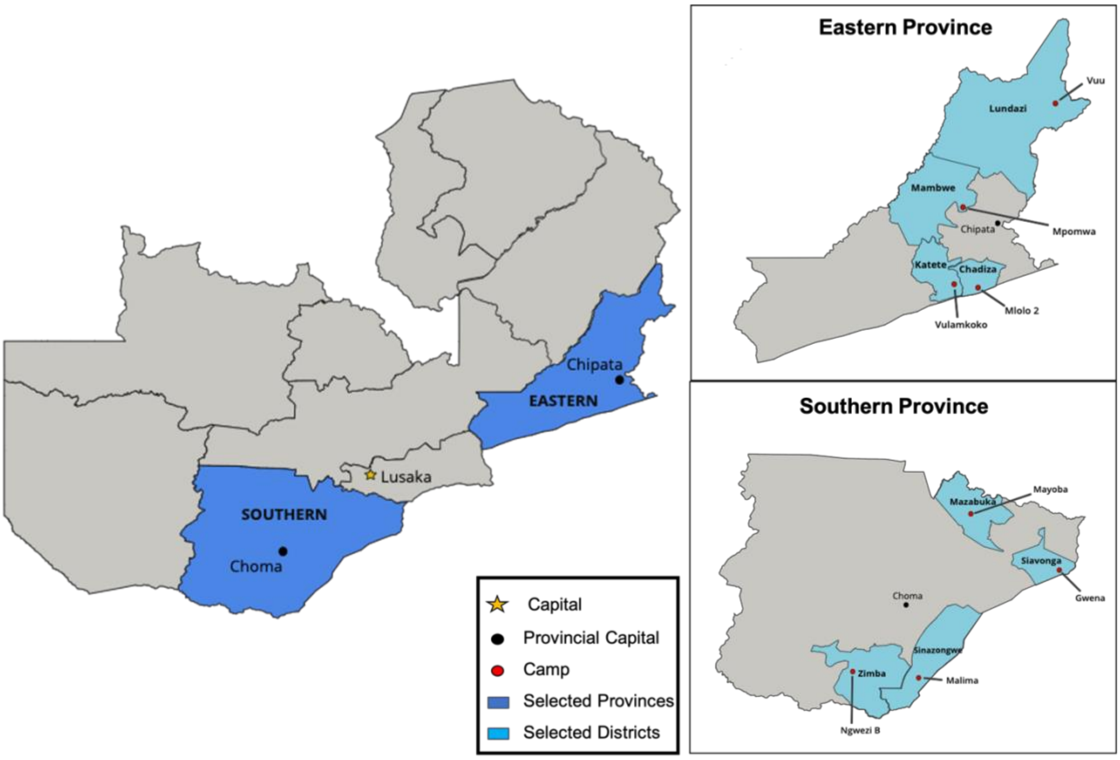

Figure 1: The selected provinces and the selected camps within each province (Phiri, 2016).

Zambia has a rapidly growing population of around 17.9 million (The World Bank, 2020). Over 50% of Zambians are employed in agriculture. Herbicide adoption rates in Zambia are low compared to the world average and were estimated to be used by only 14% of households in 2015 (Chapoto & Zulu-Mbata, 2016). The Eastern and Southern Provinces showed some of the lowest rates of adoption compared with the rest of the country. Low herbicide usage would make it more likely that there would be higher populations of weed species. Moreover, maize is grown in over 99% of households in the Eastern Province and over 94% of households in the Southern Province making them the second and third largest producers of maize in the country (Chapoto & Zulu-Mbata, 2016). The cultivation of a major cash crop like maize would potentially harness interest in herbicides as a way to increase yields (Haggblade et al, 2017a).

Current food security measures in Zambia are focused on maize production through input and buyback programs: Federal Input Subsidy Program (FISP) and the Federal Reserve Agency (FRA) (Mwanamwenge & Harris, 2017). According to a recent study, these two programs account for over 80% of the total agricultural budget for 2021 (Sitko et al., 2011). FISP aims to supply farmers with inputs like fertilizer and hybrid maize seeds while the FRA offers to purchase maize from farmers at guaranteed prices (Mwanamwenge & Harris, 2017).

Zambia is divided into three main agro-ecological zones based predominantly on rainfall and soil type. The first, zone I, is the driest region and the smallest agro-ecological zone comprising 12% of the land in the country, primarily in the south western portion of the country (Department of Energy, 2017). Although once known to be the breadbasket of Zambia, areas in zone I experience less than 800 mm or rainfall per year and have been plagued with droughts and erratic rain patterns over the last two decades (Jain, 2007). Zone I also hosts the shortest growing season in Zambia (80- 120 days) (Department of Energy, 2011). Zone II spans across the center of the country from the Western Province to the Eastern and Northern Provinces (Jain, 2007). The average annual rainfall is between 800mm – 1000mm and the growing season lasts between 100-140 days. Zone II is further divided into Zone IIa and Zone IIb based on soil type. Zone III covers mostly the northern portion of Zambia and is the wettest (>1000mm annual rainfall) and largest zone with the longest growing season (>160 day) (Department of Energy, 2011).

4.1.1. Eastern Province

The Eastern Province was the first area of study. There are nine districts from which Lundazi, Mambwe, Chadiza and Katete were randomly selected for the study area. All of which fall within the agro-ecological zone IIa. The languages spoken in the Eastern Province consist primarily of Chewa, Nsenga, Nyanja, Tumbuka and Ngoni (Central Statistical Office, 2014a). In the study, Chewa, Nyanja and Tumbuka were encountered during the interviews.

The Eastern Province is home to nearly 1.6 million people with 87% of the population living in rural areas (Central Statistical Office, 2014a). Education levels are low as a survey conducted in 2015 found that 26% of the respondents had received no education, which was the highest in the country (Chapoto & Zulu-Mbata, 2016). The median age is 16.1 years, and the average household size is 5.2 members (Central Statistical Office, 2014a).

Agriculture is the biggest working sector in the Eastern Province and accounts for 82% of the work force (Central Statistical Office, 2014a). The size of owned land, however, is quite low. The Eastern Province has the smallest amount of land ownership in the country. Only an average of 1.9 ha are owned by households (Chapoto & Zulu-Mbata, 2016). Maize is the staple crop in the province and is cultivated in over 99% of households. Groundnuts, cotton and sunflowers are subsequently important (Chapoto & Zulu-Mbata, 2016).

4.1.2. Southern Province

In the Southern Province, research was conducted in Zimba, Sinazongwe, Mazabuka and Siavonga. These four districts were randomly selected from the 13 total districts comprising the province. Amongst these districts, Zimba, Sinazongwe and Siavonga fall within the agro-ecological zone I. Mazabuka is primarily in the agroecological zone IIa with the southern portion of the district in zone I**.** Tonga is the most widely spoken language in the Southern province with Nyanja, Lozi, Toka-leya and Ila also spoken in some parts (Central Statistics Office, 2014b). Tonga and Nyanja, however, were the only languages encountered in the interviews.

A total of 1.5 million people live in the Southern Province with the rural areas containing 75% of the population. The level of education is an average of 8.2 years for residents making it the fourth most educated province in the country (Chapoto & Zulu-Mbata, 2016). The median age of the people living there is 15.9 years. The average household size is 5.4 members but is closer to 5.7 for rural households (Central Statistics Office, 2014b). The Southern Province is also home to the highest number of polygamous households in the country (Chapoto & Zulu-Mbata, 2016). The majority of the population lives below the poverty line with an estimated 47% of the population considered to be extremely poor (Central Statistics Office, 2014b).

Agriculture, tourism and mining are the primary economic drivers for the Southern Province (Central Statistics Office, 2014b). Households have an average of 4.4 ha of land and over 50% of household heads are full-time farmers. Maize is the main staple crop, but groundnuts, sorghum and cotton are also highly cultivated (Chapoto & Zulu-Mbata, 2016).

4.2. Duration of study

Field research was carried out from December 2018 until March 2019 in the Eastern and Southern Provinces of Zambia. The time and duration of the research was selected to coincide with the rainy season (August-April) and the lean season (November -March) (Hachigonta et al., 2008; USAID, 2008). It is in the rainy season when weed populations are highest making it the best time for collecting plant specimens. This time also corresponds to the period when the previous year's crops supplies are low, and food is less accessible.

4.3. Sampling

4.3.1. Household survey

Due to the limited research on the topic in Zambia the study was designed to explore the potential relevance of edible weeds and herbicides amongst smallholder famers. Therefore, a randomized sampling method was used to provide an unbiased representation of smallholder farmers in the Eastern and Southern Provinces. The two provinces were predetermined but the districts, camps and farmers were randomly selected. A camp refers to an agricultural camp, which is composed of multiple villages within a designated area as defined by the Ministry of Agriculture (MoA). Each camp has a Camp Extension Officer (CO) who is in charge of agricultural activities within the camp. Eight districts were randomly selected using an online randomizer application: randomizer.org.

In each of the selected districts the District Agricultural Coordinator (DACO) was notified of the study and then asked for a list of the total number of accessible camps in the district. Due to the heavy rains from the rainy season some camps were inaccessible by vehicle and were therefore excluded. Using the randomizer application, one camp was selected from the district. The DACO then facilitated contact with the CO who was notified of the research and asked to aide in the sampling process.

There were only two criteria used to determine the selection of households for the interviews: involvement in farming activities in the previous farming season and accessibility by vehicle or foot. The CO's provided a list of accessible farming households from the camp of which 20-35 households were randomly selected for interviews (Table 1). The lists acquired from the CO's were often incomplete and composed mainly of individuals who were a part of a farmer's group, co-op or were a FISP recipient. From each household, the head of the household and the individual responsible for food were interviewed. The CO's often facilitated meetings with the households and helped organize the interviews in advance when possible.

Table 1: Household Interview Selection Process

Province	District	Total Camps	Accessible Camps	Selected Camp	Total Households	Accessible Households	Selected Households
Eastern Province (9 Districts)	*Lundazi*	44	39	*Vuu*	600	116	20
	Mambwe	13	5	*Mpomwa*	2900	800	25
	Chadiza	16	13	*Mlolo 2*	3818	357	25
	Katete	20	14	*Vulamkoko*	1870	1870	25
Total Eastern Province	**4**	**93**	**71**	**4**	**9,188**	**3,143**	**95**
Southern Province (13 Districts)	*Zimba*	13	11	*Mayoba*	1821	393	30
	Sinazongwe	22	15	*Malima*	2100	1300	35
	Mazabuka	22	19	*Ngwezi B*	283	283	30
	Siavonga	10	7	*S. Gwena*	322	106	30
Total Southern Province	**4**	**67**	**52**	**4**	**4,526**	**2,082**	**125**
Total	**8**	**160**	**123**	**8**	**13,714**	**5,225**	**150**

Each household interview was divided into two sections: one for the head of the household and the second for the person responsible for food in the household. For the majority of the households this meant that the husband and the wife were both interviewed with the husband as the head of the household, and the wife as the person responsible for food. Single headed households were encountered where the head of the household and the person responsible for food were the same person.

Polygamy is also common in the region of study. Depending on the case, polygamous households were treated as a single headed household (one wife being both the head and the person responsible for food) or interviewing the husband and the first wife respectively as the head of the household and the person responsible for food. The researcher evaluated each case with the research assistant after speaking with the husband and wife to determine who would be able to provide the most accurate information based on the dynamic of the household. In the case that the husband was not actually living with the wife and only aided in farming activities the wife was interviewed as both the head of the household and the person responsible for food. If the husband was living in the household and appeared to be in charge of the farming activities he was interviewed as the head of household with his first wife (or the wife with whom he lives) as the person responsible for food.

4.3.2. Guided field walk

Within each camp it was necessary to use local guides to find the plants that were discussed in the interviews and focus groups for collection. The guides were selected based on the individual's level of knowledge about edible weeds. The individuals in the camp who were perceived to be the most knowledgeable about the identification and usage of the edible weeds were asked to participate in the study. The guides were chosen with the help of the CO, based on personal observation in household interviews or through community recommendation from focus group participants. One to two guides were selected in each camp based on the number of field walks conducted. One guide was used per field walk with different guides used for multiple field walks. Changing guides provided a new area for locating plants and saved the time of the individual guides who volunteered for the position.

During the field walk guides were asked about the collection or harvesting methods for edible weeds. The guide would then explain the parts of the plants that were collected and provide a demonstration on how they collect them. In the case that the edible weed shown by the guide was the only one visible for that species the guide was asked to demonstrate using a different neighboring plant. Miscommunication resulted where the guide would demonstrate on the plant that was intended to be collected for pressing and later identification. This resulted in only one damaged specimen that was still able to be identified.

4.3.3. Household demographics

The goal of the study was to interview 20 households in each of the 8 camps visited with a total of 160 interviews. Overall, out of the 160 interviews 158 were successfully completed. The two missing interviews were a result of one household in Vuu being inaccessible due to the rain and only a half interview being completed in Mpomwa. During the interview in Mpomwa, the head of the household completed their interview but the person responsible for food decided that they no longer wanted to participate in the study. Time constraints prevented the possibility of replacing these two interviews.

Household heads were predominantly male. The average age for a household head was 46 years (SD = 13.3). There was a total of 47 single headed households of which 89% were female. The person responsible for food was always female except in the case when the head of a single headed household was male, under which case the head of the household was also the person responsible for food.

Farming was the primary occupation of the vast majority of the households interviewed in both the Eastern and Southern Provinces. Eight heads of households listed a non-agricultural job as their primary source of income and only three listed casual labor on a farm outside of their own as their primary occupation. In addition, 98% of the persons responsible for food listed farming as their primary occupation. Experience ranged amongst the head of the households from 1 to 50 years for farming. The study found an average of 19 years (SD = 11.8 years) of farming experience for the sampled households (Table 2).

Table 2: Characteristics of respondents.

	Head of Household	**%** *n=159*	**Person Responsible for Food**	**%** *n=111*	**Single Headed Households**	**%** *n=47*
Gender						
Male	112	70%	0	0%	5	11%
Female	0	0%	111	100%	42	89%
Age						
<20	1	1%	2	2%	0	0%
20-29	15	9%	28	25%	4	9%
30-39	23	14%	35	32%	10	21%
40-49	34	21%	26	23%	12	26%
50-59	23	14%	15	14%	10	21%
60<	16	10%	5	5%	11	23%
Occupation						
Farmer	103	65%	107	96%	46	98%
Casual Labor (off-Farm)	3	2%	1	1%	0	0%
Causal Labor (other-Farm)	2	1%	2	2%	0	0%
Salaried	4	3%	0	0%	1	2%
Student	0	0%	1	1%	0	0%
Farming Experience						
< 5 years	11	7%	na	na	4	9%
5 - 10 years	23	14%	na	na	11	23%
11 - 20 years	38	24%	na	na	12	26%
21 - 30 years	20	13%	na	na	12	26%
30 < years	20	13%	na	na	8	17%
Education						
no education	10	6%	17	15%	8	17%
<5 years	20	13%	24	22%	14	30%
5 - 7 years	37	23%	45	41%	15	32%
8 - 10 years	31	19%	19	17%	5	11%
> 10 years	14	9%	6	5%	5	11%

4.3.4. Household size and land management

For the purpose of the study, a household was defined as all of the individuals living in the household within the last six months and including all of the children of the head of the household who reside at least part of the year in the household (i.e., children who go to boarding school). The sizes of households ranged from 1-19 members with an arithmetic mean of 6.5 members in the Eastern Province (SD = 3.08) and 6.7 members in the Southern Province (SD = 3.04).

The size of cultivated land by households varied from .25 ha to 11.6 ha. The average cultivated land in the Eastern Province was 2.71 ha (SD = 1.98) and 2.80 ha (SD = 2.23) in the Southern Province. Maize was the most important crop cultivated in both provinces. 100% of the households grew maize in the Eastern Province and 96% in the Southern Province. In addition to maize, groundnuts, soy and sunflower were important crops in the Eastern Province whereas in the Southern Province groundnuts and cotton were prevalent.

Table 3: Description of households from the study regarding the number of household members, types of crops grown and the amount of land that is cultivated.

	Eastern Province		Southern Province	
Household Size	***Households***		***Households***	
1-2 members	5		5	
3-5 members	24		28	
6 - 8 members	34		22	
>9 members	16		25	
Crops Grown	***land (ha)***	***Households***	***land (ha)***	***Households***
Bambara Nuts	.25	1	1.75	3
Beans (mixed)	2.23	6	3.7	9
Cassava	0	0	.5	1
Cotton	17.47	23	30.65	26
Cowpeas	.375	2	6.15	13
Groundnuts	43.91	54	18.38	32
Maize	104.98	79	129.05	77
Millet	0	0	3	5
Sorghum	0	0	9.4	12
Soybean	28.68	37	1.25	2
Sunflower	18.27	35	11.9	13
Sweet Potato	0	0	.69	4
Tobacco	1.5	1	0	0
Sun Hemp	0	0	5	2
Watermelon	0	0	1	1
Land Cultivated	***Households***		***Households***	
<.5 ha	2		4	
.5 - 1 ha	15		8	
1.1 - 2 ha	23		27	
2.1 - 5 ha	30		31	
5.1 - 10 ha	8		9	
> 10 ha	0		1	

4.4. Research partners

The study was conducted with the Indaba Agricultural Policy Research Institute (IAPRI) (IAPRI, 2019). IAPRI is a non-profit research and outreach organization based in Lusaka, Zambia. The organization is dedicated to creating policy solutions in Zambia as a way to combat hunger, malnutrition and poverty through the transformation of Zambia's agricultural sector. IAPRI has conducted a large number of studies throughout Zambia and acted as a base for the project providing a list of highly qualified research assistants, aiding in acquiring transportation and providing supplies for the field. Research assistants were a necessity for translating interviews. Two assistance were hired for each province that specialized in field research and conducting interviews in the prominent languages of the regions. The fieldwork for this project was also carried out in tandem with researcher Carolin Schweizerhof who focused her study on the knowledge and perception of edible weeds and herbicides in the Eastern and Southern Provinces of Zambia.

4.5. Data collection

4.5.1. Household interviews

The Eastern Province was the site of the pre-testing for the questionnaires. The pre-testing took place in the capital of the province, Chipata. Two farming households were randomly selected from the Ministry of Agriculture (MoA) to test the questionnaires and train the research assistants.

Paper questionnaires were printed out and used to record answers during the household interviews. Each interview was organized with the help of the camp officer and/or lead farmer. The majority of the interviews took place at the homes of the participants. It was ideal to have the interviews at the households because it allowed for additional observation. This was not always possible or convenient for the respondents and so interviews were also carried out near their places of work (agricultural fields, mills, etc.) or at community houses (Figure 2).

Each interview had one researcher (myself or Ms. Schweizerhof) and one research assistant. The research assistants translated the questions and the answers to the respondents and recorded them in written format. The researchers made careful observations and checked the answers for accuracy against respondent bias. This data was then entered and stored into a MS Excel spreadsheet at the end of every day.

The questionnaire contained 264 questions in total, formatted in the styles of yes/no, multi-answer and single answer multiple choice, free listing, rating, ranking and Likert scale. The section for the head of the household was the longest with 161 questions. The person responsible for food's section contained 103. Visual aides were used when necessary, in order to clarify questions and answers. A handful of 20 beans were used to represent percentages for households in order to allocate which occupations generated the most income for the household and also which locations were most important for collecting edible weeds (Figure 3). In addition, respondents were not always certain about the types of herbicides that they were using. In this case, the respondents would bring the bottle for verification and then the product would be photographed and documented. This, however, was not possible for most households for a variety of reasons. Some of the households did not actually own they herbicide and maybe never even saw the bottle, some had already disposed of the bottle and other times the interviews took place outside of the residence of the respondent and therefore there was no access to the bottle.

Figure 3: The head of household in Mlolo 2 uses beans to show the proportion of income generated for his household (Vehre, 2019).

Figure 2: A household interview that took place in Gwena sitting outside of a community house. Research assistant, Fabiano Tembo, is filling out the questionnaire as the head of the household gives responses (Vehre, 2019).

Household interviews took between 2 – 4 hours to complete. The questionnaire was divided into several themes (Table 4). For the head of the household (HoH) this included the household demographics, farm description, pesticide usage and the knowledge and perception of herbicides, nutrition and edible weeds. The section for the person responsible for food (PRF) covered the usage of weeds, household food security and also knowledge and perception of herbicides, nutrition and edible weeds. The interviews were conducted with both the HoH and the PRF together except for the sections about knowledge and perceptions. The knowledge and perception segments contained questions that were the same for both respondents. During this part, the other interviewee was sent away to prevent any influence in the answers given. The interviewees were kept together during their individual sections because it was found that their roles often overlapped, and the respondents could provide more accurate information when interviewed together.

Table 4: Section descriptions of the questionnaires for both the head of the household and the person responsible for food as well as the head of single headed households.

Respondent	**Section Descriptions**					
	Household Demographics	**Farm Description**	**Possible Usage: Herbicides, Insecticides, Fungicides**	**Weed Usage**	**Food Security**	**Knowledge and Perception of Herbicides, Nutrition and Edible Weeds**
Head of Household *(n=112)*	✓	✓	✓			✓
Person Responsible for Food *(n=111)*				✓	✓	✓
Single Head of Household *(n=47)*	✓	✓	✓	✓	✓	✓

4.5.2. Guided field walk and plant identification

In the discussion of plants and their uses, individuals most commonly referred to them by their vernacular names. These names varied greatly between camps and sometimes even within the same community. One common example needing clarification arose with the identification for different species within the genus *Amaranthus* (as seen in Figure 4). The plants falling into this genus were often interchangeably called variations of Bondwe, Bata, Bonko, etc., depending on the community. Guided field walks were used to clearly identify the plants discussed in the household interviews and in the focus group discussions. During the household survey the person responsible for food was asked to list all of the edible weeds that the household collects and consumes. Similarly, in the focus group discussions participants were asked to collectively list all of the edible weeds that they know.

Figure 4: Three examples of different species that share the same local names in the genus Amaranthus (Vehre, 2019).

In each of the eight camps a list was made of all of the names given in the completed questionnaires and in the focus group discussions on edible weeds. One to two field walks were conducted in each camp with 14 field walks completed in total. In each field walk, the guide directed me, along with a research assistant, to the listed plants in communal lands, agricultural fields, gardens, pathways and around households. Photographs were taken of each plant including the plant in its habitat, and with a white background in order to make its features more distinguishable. The photographs were used as an aide for identification in pair with collecting voucher specimens. The photographs were conducted in part under the proposed photographic standards listed by Baskauf and Kirchoff (2008). The photographs were used to capture traits of the plants could be lost in pressing and drying (i.e. color, habitat and living morphology) (Baskauf & Kirchoff, 2008).

Voucher specimens were collected in accordance with the guidelines suggested by Bowles (2004) and with the guidance of the University of Zambia's (UNZA) department of biological sciences. The walks took place in the early mornings and the evenings when the temperatures were cooler, and the lighting was still good for photo documentation.

Samples were collected with the permission of the landowner and/or household head. One sample was collected with the first encounter of each species that was at least in the vegetative stage or in the stage when the guide would typically collect the plant to be used. A second sample of each species was collected when the species was encountered during the flowering stage if it was not previously collected during this stage. Collection during the flowering stage is ideal because some plants can only be identified until the genus without inflorescence.

Each collected plant was be tagged with the local name, date, name of collector, GPS coordinates, collection number. The collection number is composed of the camp ID (100-800) and the ascending number of collection order (1, 2, 3, etc.). There were 150 plants listed in the study by their local name as edible weeds. Of these plants, 38 were not able to be found either because the plants were unavailable at the time or because the plants did not actually grow in agricultural fields and was therefore deemed irrelevant for the purpose of the study. Photographs were made of all of the plants found in each community including those not collected. In total, 76 plant individuals were collected, and 112 plant individuals were photo documented (Table 5).

Table 5: The number of individual plants collected and documented in each district.

Province	District	Plants Listed by Vernacular Name	Plants Collected	Plants Photo Documented
Eastern Province	*Lundazi*	15	9	12
	Mambwe	15	14	14
	Chadiza	15	11	13
	Katete	10	5	8
Total		**55**	**39**	**39**
Southern Province	*Zimba*	24	15	23
	Sinasongwe	33	11	20
	Mazabuka	17	4	8
	Siavonga	21	7	14
Total		**95**	**37**	**65**

When possible, the whole plant, including its roots, was collected. Pressing was not always possible in the field and therefore plastic bags were used for temporary storage. The plants were placed in a plastic bag carefully so as not to break or damage the specimen. Air was blown into the bag and then tied in order to create a bubble that will add protection from bruising while maintaining moisture levels needed for preservation. The plants were stored for a maximum of one hour to prevent significant wilting pre-pressing.

For preservation, the plants were placed flat in newspapers inserted between blotting paper and pressed using a standard plant press. The blotting paper was replaced after 24 hours and then again, each day as necessary until the plants were fully dried out. It is important to dry the plant species quickly in order to preserve the color. Complications arose from the high moisture of the rainy season when the sun was not strong enough to dry the plants. Traditional cooking stoves, known as blazers, were used to expedite the drying process and prevent mold. While pressing, careful consideration was made regarding: the visibility of distinguishable traits, prevention of overlapping parts, and fitting the specimen so that it could later be mounted onto a standard herbarium sheet (420x297mm) (Hildreth et al., 2007).

The identification process was first examined in the field with the aid of two guidebooks: (Vernon, 1983; Fowler, 2007). These books provided a list of common vernacular names through several language groups and linked these names to the possible scientific names. Collaboration was made with UNZA for the official identification of the edible weeds. All of the pressed specimens and photographs of specimens were given to the department of biological sciences at UNZA to identify. The working botanist identified the specimens utilizing the Flora Zambesiaca (Flora Zambesiasca) and acquired the scientific names based on “The Plant List” (The Plant List, 2010) and the Angiosperm Phylogeny Group, 2016. The identifications were later cross-referenced with the World Flora Online for consistency (WFO, 2020). The mounted specimens are currently kept in the university’s herbarium.

The Eastern Province was the first area of study. During this time the weeds were at their youngest stages of development. As a result, many of the weeds were collected during the vegetative stage which is when the plants are collected for consumption but not easily identifiable. The flowering or inflorescent stage is best for identification to the species level. Furthermore, due to the collection of local names beyond the household interviews, 24 identifications were made from the collected edible weed plants that were either not listed as being consumed in the interviews or unable to be associated with the local names provided during the household interviews.

4.6. Data storage and analysis

4.6.1. Data storage

During the household interviews, the research assistants recorded data in written format directly into the questionnaires. At the end of each day the answers to the questionnaires were transferred into an Excel sheet to be checked for any missing information or incongruencies in responses.

Photos of the plants from the field walks were regularly uploaded onto an external hard drive in the field. Notes were handwritten from the field into a notebook for later reference. All of the relevant information was recorded into an Excel sheet. The scientific names acquired from the field walks were integrated into the results from the questionnaires to evaluate in place of the vernacular names. All of the data, except for the plant photos, were uploaded onto Dropbox as a backup when there was internet access and stored onto a USB flash drive or external hard drive. The photographs were too large to store on Dropbox and were therefore stored only on external hard drives.

4.6.2. Analysis

The data collected from the field was analyzed using Microsoft Excel (16.45) and R. Descriptive statistics (i.e., arithmetic mean, frequency, and range) were analyzed first to understand the demographics, socio-economic characteristics, edible weed consumption habits and herbicide usage patterns. The scientific names of the identified edible weeds were used to in place the vernacular names given in the questionnaire for analysis.

Based on the descriptive data, perceived influential variables (independent variables) were selected for possible correlation to edible weed consumption patterns (dependent variables) based on the number of edible weed species consumed and the arithmetic mean of the rate of edible weed consumption (days of edible weeds consumed/household/month). The independent variables were selected based on three categories: Demographics, household food security and herbicide usage. The correlation was calculated using Spearman's correlation with a significance level of 5%.

4.7. Return of results

The study was aided with the help of a number of individuals from IAPRI and members of the MoA, many of whom expressed interest in the outcome of the results. Email addresses were asked for all of the interested participants. Upon the completion of the thesis the final results will be sent via email to those who requested it. The data from the questionnaires will also be given to IAPRI so that they may use it in their research. The collected plant specimens were mounted and are already stored in the herbarium at UNZA.

5. Results

5.1. Edible weed classification and usage

5.1.1. Edible weed identification

Every household in the study consumed edible weeds and collected edible weeds. Cumulatively, amongst the 157 persons responsible for food (PRFs), weeds were listed as being consumed 550 times amounting to 22 identified edible weeds belonging to 15 families (Table 6). Households consumed an arithmetic mean of 3.5 weed plants per household with each household consuming at least one, and at most ten different weeds.

In the Eastern Province, 11 species and 2 genera (*Amaranthus* and *Bidens*) were identified along with 13 species and 3 genera (*Amaranthus*, *Bidens* and *Tribulus*) in the Southern Province. Five species of the *Amaranthus* genus (*Amaranthus graecizans, Amaranthus graecizans* subsp. *Silvestris, Amaranthus spinosus, Amaranthus viridis,* and *Amaranthus hybridus*) and two species of the *Bidens* genus (*Bidens schimperi* and *Bidens pilosa*) were discovered to be consumed by households in both provinces. The overlapping local names within these two genera, however, made it impossible to discern the exact species during the household interviews and therefore, each were only referred to by their genus. Two identified edible weed plants were listed by households as not being consumed yet known to be edible.

The identifications were made using the 137 listed distinct local names for edible weeds gathered from the household interviews and focus group discussions within both provinces (55 local names from the Eastern Province and 82 from the Southern Province). Cumulatively, there were 22 local names that were unable to be identified. These unidentified species account for the 12 times that unknown edible weeds plants were listed in the Eastern Province and the 27 times that they were listed in the Southern Province. It is not certain how many of the unidentified local names are the same or different species.

Table 6: The identified weed species in both the Southern and Eastern Provinces that are consumed by households (n=157).

Scientific Name	Voucher Numbers	Family	Food			Medicine	Fodder	Income	Preserved	Cultivated 2017	Cultivated 2018	Parts Collected	Parts Used
			Eastern Province n=77	Southern Province n=80	Total Frequency *n=157*	*n=157*	*n=157*	*n=157*	*n=157*	*n=157*	*n=157*		
Amaranthus sp.	*22253, 22223, 22256, 22257*	Amaranthaceae	65	73	138	43%	76%	6%	10%	10%	5%	Whole, leaves, young stem with leaves	Leaves, young stem with leaves
Corchorus olitorius L.	*22270*	Tiliaceae	62	61	123	2%	46%	3%	61%	0%	0%	Whole, leaves, young stem with leaves	Leaves, young stem with leaves
Bidens sp.	*22258, 22261*	Asteraceae	69	32	101	15%	40%	1%	52%	0%	0%	Whole, leaves, young stem with leaves	Leaves, young stem with leaves
Ceratotheca triloba (Bernh.) Hook.f.	*22216*	Pedaliaceae	18	30	48	6%	20%	1%	22%	1%	1%	Leaves, young stem with leaves	Leaves, young stem with leaves
Cleome gynandra L.	*22265*	Cleomaceae	8	20	28	3%	10%	1%	10%	3%	1%	Leaves, young stem with leaves	Leaves, young stem with leaves
Hibiscus cannabinus L.	*22277*	Malvaceae	19	1	20	1%	4%	1%	1%	3%	1%	Leaves, young stem with leaves	Leaves
Cleome monophylla L.	*22211*	Cleomaceae	0	7	7	0%	3%	0%	3%	0%	0%	Young stem with leaves	Leaves
Cucumis c.f. *anguria* L.	*22217*	Cucurbitaceae	3	1	4	1%	2%	0%	1%	0%	0%	Leaves, fruit	Leaves, fruit
Jacquemontia tamnifolia (L.) Griseb	*22229*	Convolvulaceae	0	3	3	0%	1%	0%	0%	0%	0%	Leaves, young stem with leaves	Leaves, young stem with leaves
Portulaca oleracea L.	*22245*	Portulacaceae	0	3	3	0%	2%	0%	0%	0%	0%	Young stem with leaves	Young stem with leaves
Alternanthera sessilis (L.) DC.	*22235*	Amaranthaceae	0	2	2	0%	1%	0%	0%	0%	0%	Young stem with leaves	Young stem with leaves
Commelina benghalensis L.	*22214*	Commelinaceae	0	2	2	0%	1%	0%	0%	0%	0%	Young stem with leaves	Leaves, young stem with leaves
Commelina africana L. var. *lancispatha* C.B. Clarke	*22230*	Commelinaceae	0	2	2	0%	1%	0%	0%	0%	0%	Young stem with leaves	Leaves
Crotalaria c.f. cleomifolia Welw. ex Bak.	*22273*	Fabaceae	2	0	2	0%	1%	0%	1%	0%	0%	Whole	Leaves
Euphorbia oatesii Rolfe	*22276*	Euphorbiaceae	2	0	2	0%	0%	0%	0%	0%	0%	Whole, young stem with leaves	Leaves
Tithonia diversifolia (Hemsl.) A. Gray	*22215*	Asteraceae	0	2	2	0%	0%	0%	0%	0%	0%	Young stem with leaves	Young stem with leaves
Aerva leucura Moq.	*22248*	Amaranthaceae	1	0	1	0%	1%	1%	0%	0%	0%	Young stem with leaves	Leaves
Ormocarpum kirkii S. Moore	*22280*	Fabaceae	1	0	1	0%	0%	0%	0%	0%	0%	Young stem with leaves	Leaves
Sesamum c.f. *angolense* Welw.	*22281*	Pedaliaceae	1	0	1	0%	0%	0%	0%	0%	0%	Leaves	Leaves
Solanum nigrum L.	*22219*	Solanaceae	0	1	1	0%	1%	0%	0%	0%	0%	Young stem with leaves	Young stem with leaves
Tribulus sp. L.	*22224*	Zygophyllaceae	0	1	1	1%	0%	0%	0%	0%	0%	Leaves	Leaves
Tricliceras longepedunculatum (Mast.) R. Fernandes var. *longepedunculatum*	*22283*	Passifloraceae / Turneraceae	1	0	1	0%	0%	0%	0%	0%	0%	Whole	Leaves
Unidentified Edible Weed	na	na	7	20	27	5%	12%	1%	8%	1%	1%	Na	Na

5.2. Household consumption and collection

5.2.1. Edible weeds as food

Edible weeds are used as a relish to eat alongside a traditional maize porridge called nshima (Figure 5). The plants are typically chopped into thin pieces and then cooked down with oil, onion and sometimes tomato, green pepper or ground nuts. The cooking process creates a soft and mushy consistency that makes the relish easy to pick up and eat with a balled up and flattened piece of nshima.

Figure 5: A plate of nshima (on the right) next to a sample plate of relishes that are eaten with nshima, including Amaranthus sp. and H. Cannabinus (Vehre, 2019).

Figure 6: A young woman in Mayoba cuts Amaranthus sp. during the interview in preparation for dinner (Vehre, 2019).

Amaranthus sp., *C. olitorius* and *Bidens* sp. were the most commonly consumed edible weeds. Each of these plants were eaten by over half of the households with 88% of households using *Amaranthus* sp. for food. In addition, *C. Triloba*, *C. gynandra* and *H. cannabinus* were regularly mentioned amongst households. *H. cannabinus* was only listed in the Eastern Province and used by 13% of households, however, the actual consumption rate of this edible weed species is likely much higher.

5.2.2. Other uses for edible weeds

In addition to food, edible weeds were used as fodder, medicine and as a source of income. In fact, edible weeds were seldom only used as food. Of the total reported uses of edible weeds (f=550), 30% were used by households without any purpose other than food. However, 82% of households (n=157) listed multiple uses for edible weeds. The most important alternative was fodder in which 81% of households used edible weeds for fodder in addition to food. Edible weeds were also used as medicine by 46% of households and for income by 11%.

Before crop emergence and/or after harvests, animals are often let into the fields to graze on the weeds and remaining stubble. Occasionally, households would collect the weeds while manual weeding in order to bring some back to the animals to feed. This was witnessed during one interview when two young girls emerged from the fields behind the house carrying several chitengas (a traditional cloth) with a mix of edible weeds, including *C. triloba*, to feed to the goats.

Households listed eight edible weed species and eight unknown edible weed plants that were used for medicinal purposes. These weeds were used for a variety of medicinal purposes but were most commonly listed in the treatment of anaemia. *Amaranthus* sp. was used by 35% of PRF's for anaemia. For treatment, the leaves and young growth of *Amaranthus* sp. would be boiled in water and then filtered out. The liquid would then be consumed by the afflicted individual. Edible weeds were also used by 11% of households for treating wounds and sores predominantly with *Bidens* sp. (f=15), but also with *C. triloba* (f=1), and *C. gynandra* (f=1). *Amaranthus sp.* is the most commonly used edible weed for medicine, fodder and food. Moreover, the five most frequently used edible weeds for all three include, in addition to *Amaranthus sp.*, *Bidens* sp., *C. triloba*, *C. gynandra and C. olitorius*.

Some households also generated income from selling edible weeds. The amount of income generated in the previous farming season varied greatly by household, ranging from 5 ZMW to 1000 ZMW (0.37 EUR – 73.31 EUR) with an arithmetic mean of 174 ZMW (12.76 EUR) (SD=235.21 ZMW; 17.24 EUR). *Amaranthus* sp. and *C. olitorius* were the most frequently mentioned edible weeds used for income and were sold respectively by 9, and 5 of the 18 households which sold edible weeds. In total, seven identified edible weed species and two unidentified species were sold. Edible weeds were not highly valued for income and were often viewed as a commodity that everyone had in the community. Households listed a lack of demand due to general access to these plants as the primary reason for not selling edible weeds.

Socio-economic variables including age, gender, income, etc. were tested for correlation with the number of edible weed species eaten and the frequency of edible weed consumption per household. Only the household size ($r=-0.16$, $p=0.044$) and area of cultivated land ($r=0.17$, p=0.0035) showed a significant correlation below the 5% significance level with the number of edible weed species consumed (Table 7). Larger households appear to have consumed a fewer number of edible weed species, while households with more cultivated land tended to eat more. A significant correlation below the 1% significance level was found between the frequency of edible weed consumption and where the respondents were living (r=-0.4, p = $2.8e^{-07}$). Respondents from the Southern Province consumed edible weeds more often per month than those from the Eastern Province.

*Table 7: The correlation of socio-economic variables with the number of weed species consumed and the arithmetic mean for the frequency of edible weed consumption per household per month. Calculated with Spearman's correlation. Significance level at 5% =**, 1% = ****

Independent Variable	**Scale**	**Dependent Variable**			
		Number of weed species consumed by each household		**Arithmetic mean of the number of days that edible weeds were consumed by each household per month**	
		r Value	p Value	r Value	p Value
Location	Province: 1 = Southern, 0 = Eastern	-0.045	0.57	**-0.4**	**<0.001*** **
Gender	Gender of the HoH: 1 = male, 0 = female	-0.01	0.9	0.00048	1
	Gender of the PRF: 1 = male, 0 = female	0.019	0.82	0.0024	0.078
Age	HoH: Number of Years	0.014	0.86	0.04	0.62
	PRF: Number of Years	0.038	0.63	-0.13	0.095
Household size	Number of members	**-0.16**	**0.044** **	-0.092	0.25
Education	HoH: Number of Years	0.049	0.54	-0.03	0.71
	PRF: Number of Years	-0.006	0.94	-0.0084	0.92
Farming experience	Years	0.046	0.57	0.049	0.54
Income generated from farming	Percentage of total income	-0.051	0.53	-0.11	0.16
Total income	ZMW	0.1	0.23	0.15	0.073
Fallow land area	Area of land (ha)	0.11	0.17	.024	0.76
	Percentage of total owned land	0.042	0.6	0.0075	0.93
Cultivated land area	Area of land (ha)	**0.17**	**0.035** **	0.01	0.9
	Percentage of total owned land	-0.042	0.6	(-)0.014	0.86

5.2.3. Unused edible weeds

Even though all of the households consumed edible weeds, respondents listed some weeds that they knew to be edible but did not eat. There were 44 PRF's (28%) who reported edible weed plants that they, themselves, did not consume, which included 11 different identified weed species and four unidentified edible weed plants. O. *Kirkii* and *T. longepedunculatum* were the most unused weeds based on the proportion of times they were listed. The main reason given for both plants was that the households simply did not like the taste (Table 8). In fact, a distaste for certain types of edible weeds was the primary reason households listed for not eating known edible weeds. Edible weeds being unavailable was the second most commonly listed reason by 34% of households (100%=44). Moreover, 87% of the households that listed weeds as unavailable (100%=15), 7% specified that they were unavailable due to drought. Additional reasons why certain weeds were not eaten include, not having a need for them, not knowing how to use the edible weed, and finally, there was one household that did not consume *T. longepedunculatum* because they did not have any groundnuts to eat with it.

Table 8: The reasons, given by households, for not consuming known edible weeds. Multiple reasons were given by households. (n=157, 100%=44)

Reason for Not Using Edible Weeds	Number of Households	%
Dislike Taste	20	45%
Not Available	15	34%
Not Needed	9	20%
Lack of Knowledge	5	11%
No Groundnuts Available	1	2%

All of the weeds that were listed as uneaten were actually eaten by at least one other household except for one weed species, *Urochloa mosabicensis*. *U. mosambicensis* is a known edible weed that was listed by eight households but not actually eaten by any of them. This edible weed is a grass-like weed that was used by households in the past during times of famine. The seeds could be collected and then ground to be made into nshima when no maize was available. The collection process is highly time consuming and laborious, and therefore no longer used today. Even so, *U. mosambicensis* was not entirely unused by households. All of the households that listed *U. mosambicensis* as an uneaten edible weed did in fact use the edible weed, but as fodder instead of personal consumption. Despite some edible weeds not actually being consumed, households still used them for fodder and medicine. 66% of the households that did not eat certain known edible weeds used them for fodder and 1% used them for medicine.

5.2.4. Collection process for edible weeds

Edible weeds are collected almost entirely from in or around agricultural fields. Only 5% of households collected edible weeds from outside of their own fields. Even in this case, it is possible that they are still being collected from farmland. Several respondents explained that they collected weeds from a neighbor's or someone else's farmland in the community. All of the households collected edible weeds from fields that were cultivated in the previous farming season although 16 households, additionally, collected them from their fallow fields.

Figure 7: Young children collecting Shungwa (C. gynandra) from a maize field in Mlolo 2 (Vehre, 2019).

The leaves of the edible weed plants were consumed by all of the households regardless of species (Table 6). *C. cleomifolia* was the only weed listed where, in addition to the leaves, the fruits were also eaten. Depending on the collection process, the young stems are also eaten with the leaves. The new growth of the edible weeds with the soft, young stems and leaves are collected for 17 of the edible weed species (77%). The whole plant or just the leaves are also collected depending on maturity and the type of edible weed. If the weed is young, like *C. gynandra* depicted above (Figure 7), then gatherers will collect the plant whole, but once the bottom stem has matured, only the new growth will be collected. Other weeds, like *C. cleomifolia*, are collected whole and later, the leaves are removed for cooking.

Weeds, as defined by the study, grow wild and on, or around, agricultural fields. However, a number of respondents mentioned during the household interviews that they would collect the seeds and randomly disperse them in agricultural fields and around their households. In some cases, households even cultivated these weeds in their home gardens. Edible weed plants were listed as being cultivated 28 times during the 2018 farming season and 14 times in the 2017 farming season. This shows an increase of 100% in the number of cultivated edible weed plants from the 2017 to 2018 farming season and an increase in the number of households cultivating these plants by 83% (12 households in 2017 to 22 households in 2018).

There were four identified species of edible weeds that were cultivated by households: *Amaranthus* sp., *C. triloba, C. gynandra* and *H. cannabinus*. Two of the cultivated edible weeds were not able to be identified but were listed as having been cultivated in both the 2017 and 2018 farming season. *Amaranthus sp.* accounted for over half of the listed cultivated weeds.

5.3. The role of edible weeds in food security

5.3.1. Reasons for consuming edible weeds

Edible weeds are consumed for a variety of reasons but cultural tradition and a means to supplement one's diet were both listed by over half of the respondents in the household interviews (Table 9). In fact, when asked the question, many of the respondents seemed surprised and in one case answered, "it's just what we do". Asking this question felt concomitant with asking someone why they eat food. Many also mentioned that they like the taste and enjoy eating these plants, as 46% of the respondents eat edible weeds out of preference. Households also listed the fact that the weeds were merely accessible and present for reasons of consumption.

Table 9: The reasons for consuming edible weeds as listed by the PRF. Multiple answers were possible. (n=157)

Reasons for eating edible weeds	Number of Households	Percentage of Respondents
Supplement Diet/Lack of other food	84	54%
Tradition	83	53%
Preference	72	46%
Accessible	2	1%

Over the course of the previous five years, 132 households described a change in the quantity of edible weeds that they were eating. Edible weeds were consumed more compared to five years ago by 43 households while 52 households were eating less. Furthermore, there were 37 households that listed consuming certain edible weed species more and others less.

The reasons for eating fewer edible weeds than before follows in line with the reasons cited by households for not eating specific weed species at all: fewer plants are available and disliking the taste. The most frequently cited reason by households for changing their consumption rate was due to fewer edible weeds being available (Table 10). A total of 58 households listed, cumulatively, 104 times that they were eating certain edible weeds less because they were not as prevalent and easy to find as they used to be. Although the reason for why these plants were less abundant is not well known, nine households specified drought as the culprit while one household attributed the loss to herbicide use. Additionally, 34% of households consumed some edible weeds species less because they did not like the taste or because they preferred to eat other foods. Several households also listed more specific reasons for eating fewer edible weeds like not having enough nshima to eat with it, having a new person in charge of food preparation who does not know how to use the edible weed, and that the household did not need as much as they used to.

Households that were eating more edible weeds listed a need for more food, liking the taste and, conversely to those eating fewer edible weeds, having more edible weed plants available as the primary reasons. A means to supplement one's diet due to lack of other food was the most frequently listed reason for consuming more. Households also listed making a dietary change to either increase dietary diversity or increase the level of nutrition in the household. One case existed where the household did not previously know about an edible weed and now consumes it.

Table 10: The reasons why households have changed their rate of consumption of edible weeds over the last 5 years. Multiple answers were possible. (n=157, 100%=132)

Reason for change in Edible Weed Consumption	**Households**	
	f	*%*
Eating Fewer Edible Weeds		
Does not like/prefers other foods	45	34%
Less available	58	44%
Other	10	8%
Total	**113**	**86%**
Eating More Edible Weeds		
Needed to supplement diet	33	25%
Making a dietary change	11	8%
More available	26	20%
Like the taste	25	19%
Other	2	2%
Total	**97**	**73%**

While a change in availability of edible weeds was listed as a reason for consuming more and less edible weeds, households were rather evenly dispersed on their overall perception of the change in availability of edible weeds. The PRF's described 38% of the reported uses of edible weeds, as more available (=550), 30% as less available and 32% with no change in availability over the last five years. Moreover 60% of PRF's (n=157) saw an increase in edible weed prevalence while 51% saw a decrease and 24% of households saw an increase in certain edible weed plant abundance and a decrease in others.

5.3.2. Household food security and nutrition

Edible weeds are consumed throughout the entire year, however, they are consumed at the highest rates during the rainy season from December until March (Figure 8). January is when edible weeds are consumed the most frequently in which households consumed edible weeds fresh an average of 22 times in the month (SD = 6.3). This is also the time when the weeds are the most abundant and predominantly eaten fresh (prepared without processing after collection). Furthermore, the peak times of edible weed consumption are also the months that households described their food security to have been either "bad" or "very bad". The highest rates of food insecurity were in January and February 2017 where, respectively, 26% and 28% of households were food insecure.

In addition to consuming the plants in their fresh form, some edible weeds are preserved by means of drying. *C. olitorius*, *Bidens* sp. and *C. gynandra* were the most frequently preserved edible weeds. This process is done by laying the weeds out on a tarp in the sun so that the weeds can be stored and saved for later use. Edible weeds were preserved by 137 households who preserved between 1 and 5 edible weeds. Of these households, 99% explained that this was done in order to ensure food security for the future. The months when edible weeds were consumed the most frequently in their preserved form were August through October 2018. Weeds were not preserved only for food security though, there was also the reason that the weeds were dried because it tastes better. This was the case mentioned for *Bidens sp.* and *C. triloba* where 3 households listed preserving these weeds out of preference.

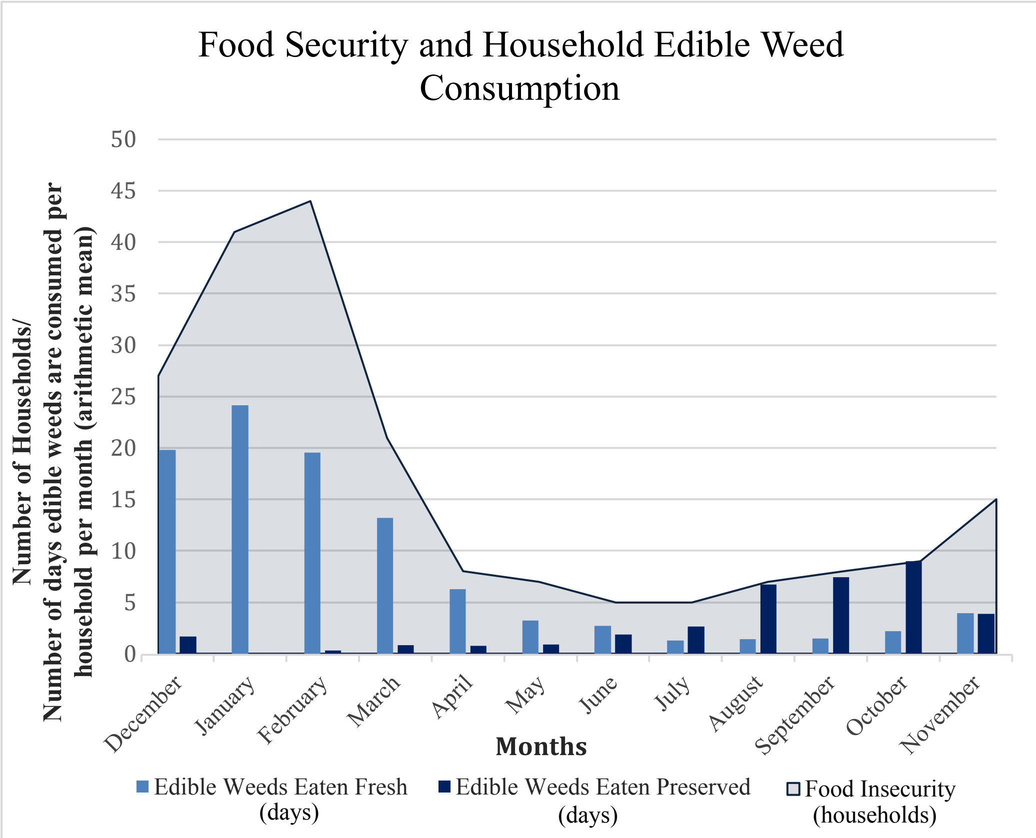

Figure 8: The line graph in the foreground represents the number of households that experienced food insecurity in each month (n=157). Additionally, the bar graph shows the arithmetic mean of the number of days that edible weeds were consumed per households in each month either fresh or preserved (n=157).

Edible weeds were considered to be highly important in times of food scarcity (Table 11). Both the HoH and the PRF were asked about their perception on the relevance of edible weeds for food during times when food was insecure. Cumulatively, 87% agreed that they are important with 77% strongly agreeing. Conversely, 11% of respondents found edible weeds to not have any pertinent role in food security. Although accepted by the majority as important for food security, some debate arose on whether edible weeds are nutritious or just “stomach-fillers”. When asked to rank the nutritional value of edible weeds, 17% of respondents said that they had low, or no nutritional value. Still, however, 83% of respondents found that edible weeds had a high or very high nutritional value.

Table 11: The perception of the HoH and the PRF from the household interviews on the importance of edible weeds during times of Food Scarcity.

Perceived Importance of edible weeds during Food Scarcity	**HoH**		**PRF**		**HoH & PRF**	
	f	**%**	***f***	**%**	***f***	**%**
Strongly Disagree	12	8%	11	10%	23	9%
Disagree	1	1%	5	5%	6	2%
Neutral	6	4%	1	1%	7	3%
Agree	17	11%	9	8%	26	10%
Strongly Agree	123	77%	85	77%	208	77%
Unsure	0	0%	0	0%	0	0%
Total	159	100%	111	100%	270	100%

Food security variables, based on household yield of the main staple (maize) and the household's perception on their own food security, as well as the role that edible weeds play in food security, were tested to correlate with edible weed consumption (Table 12) A negative correlation was found for maize yields (r=-0.16, p=.043) indicating that lower yields may increase the frequency of edible weed consumption. Additionally, households with a HoH or PRF who viewed edible weeds to be important in times of food scarcity were more likely to consume a wider range of edible weed species and to have a high frequency of consumption. There was no correlation between the households perceived level of food security and edible weed consumption rate.

*Table 12: The correlation of variables related to household food security with the number of weed species consumed and the arithmetic mean for the frequency of edible weed consumption per household per month. Calculated with Spearman's correlation. Significance level at 5% = **, 1% = ****

Independent Variable	Scale	Dependent Variable			
		The number of weed species consumed by each household		The arithmetic mean of the number of days that edible weeds were consumed by each household per month	
		R Value	P Value	R Value	P Value
Food accessibility					
Yield of main stable (Maize)	Yield kilos/ha	-0.12	0.13	**-0.16**	**0.043****
Perceived Food Security					
Food security	Number of months "Bad" and "Very Bad"	0.04	0.62	0.012	0.88
	All levels of Food Security (1-Very Good, 2-Good, 3-Ok, 4-Bad, 5-Very Bad) Total Count (Highest numbers are the most food insecure: Highest possible food security = 12; Worst possible food security = 60)	-0.036	0.65	-0.0057	0.94
Edible weeds are especially important in times of food scarcity	HoH: 1 (Strongly Disagree) - 5 (Strongly Agree)	**0.17**	**0.03****	**0.27**	**.00079*****
	PRF: 1 (Strongly Disagree) - 5 (Strongly Agree)	**0.21**	**0.031****	**0.25**	**0.0072*****
	PRF & SHoH: 1 (Strongly Disagree) - 5 (Strongly Agree)	0.15	0.064	**0.21**	**0.0099*****

5.4. Herbicide trends

5.4.1. Herbicide usage and application

Herbicides were used by 34% of households (n=159). An arithmetic mean of .75 ha per household were sprayed with herbicides equating to 27% of the household's cultivated land (Table 13). Edible weeds were collected from an arithmetic mean of .54 ha per household where herbicides were applied accounting for 72% of the fields that were sprayed. Moreover, the majority of households applied herbicides during the peak times of edible weed collection. Households began spraying their fields as early as November but 84% of households applied herbicides in December and 65% in January (Figure 9).

Table 13: The arithmetic mean of land area (ha) where edible weeds are collected and herbicides are applied per household along with the percentage of the cumulative cultivated land dedicated to herbicides application and edible weed collection.

Land Application/ Use	**Cultivated Land per Household** *Average (ha)*	**% Total Cultivated Land** *441.09 ha*
Herbicides Used	.75 (SD=1.62)	27%
Edible Weeds Collected	1.76 (SD=1.56)	65%
Herbicides Used & Edible Weeds Collected	.54 (SD=1.37)	20%
No Herbicides & No Edible Weeds Collected	.76 (SD=1.24)	28%

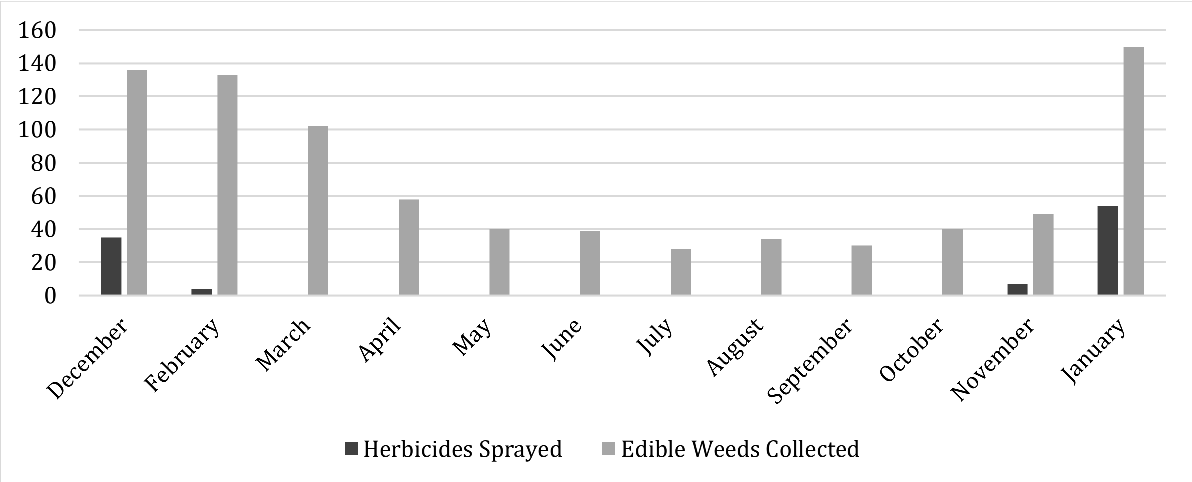

Figure 9: The number of households that applied herbicides and collected edible weeds in each month of the previous farming season (=55).

The usage of herbicides did not demonstrate an effect on edible weed consumption amongst households. Actual herbicide usage and perceived herbicide usage variables were tested to find a correlation between edible weed consumption and herbicide use (Table 14). However, no significant correlation was found in regard to any of the selected parameters.

*Table 14: The correlation of perceived and actual herbicide usage variables with the number of weed species consumed and the arithmetic mean for the frequency of edible weed consumption per household per month. Calculated with Spearman's correlation. Significance level at 5% = **, 1% = ****

Independent Variable	**Scale**	**Dependent Variable**			
		The number of weed species consumed by each household		**The arithmetic mean of the number of days that edible weeds were consumed by each household per month**	
		R Value	P Value	R Value	P Value
Herbicide Usage					
Herbicide adoption	Number of herbicides	-0.052	0.52	-0.13	0.12
	1= yes, 0 = no	-0.038	0.64	-0.12	0.13
	Number of years	-0.1	0.21	-0.057	0.48
Herbicide application area	Land area (ha)	-0.1	0.21	-0.07	0.38
	Proportion of land (%)	-0.12	0.14	-0.059	0.46
Quantity of herbicides applied	Herbicides sprayed per field (L/ha)	-0.19	0.17	0.19	0.18
Perception of herbicide usage					
Fewer edible weeds are available as a result of herbicide usage.	HoH: 1 (Strongly Disagree) - 5 (Strongly Agree)	0.11	0.22	0.062	0.47
	PRF: 1 (Strongly Disagree) - 5 (Strongly Agree)	0.14	0.17	-0.15	0.16
	PRF&SHoH	0.068	0.44	-0.12	0.17
How accessible are herbicides compared to the last 5 years?	HoH: 1 (Much more difficult to find) - 5 (Much easier to find)	0.023	0.79	0.049	0.57
How accessible are herbicides?	HoH: 1 (Very difficult to find) - 5 (Very easy to find)	-0.01	0.9	-0.07	0.4
I would like to adopt (more) herbicides into my future farming practice.	HoH: 1 (Strongly Disagree) - 5 (Strongly Agree)	0.075	0.35	-0.11	0.17

Herbicides were primarily used as a means to combat weed pressure. Weed pressure and a desire for more effective weed removal were listed by 93% of households. Reducing labor was the second most frequently listed reason for herbicide adoption, which accounted for 29% of households. Additional reasons like, improving yields, saving time and money were also listed. One household used herbicides to improve soil fertility and another household listed the need to use herbicides in order to adapt to conservation agriculture practices.

Households that used herbicides, applied between one and four different herbicides in the previous farming season. During the interviews, households listed all of the herbicides that they had used. However, recalling the names and types of herbicides was often problematic. It was common for respondents to be unsure of the herbicide product that they were using and only recall the active ingredient in the case of glyphosate and mesotrione.

Figure 10: Photos of herbicides that were used by farmers from the household interviews (Vehre, 2019).

Without distinguishing between active ingredients or brand names, herbicides were listed a total of 73 times in the household interviews (Table 15). From which, only 20 products were able to be identified. Glyphosate was the most commonly listed herbicide accounting for 11 different products and 24 unknown glyphosate products. Atrazine in mixture with mesotrione, nicosulfuron or cyanazine and mesotrione where the next most commonly used herbicides. Suppliers from China, Hong Kong or India manufactured at least 11 of the known products. The remaining nine products came from suppliers from Germany, South Africa and the United States.

There were nine cases where the herbicides were entirely unknown to the household and 13 products that were named by the respondents without knowledge of the active ingredients and without the ability to confirm the product brand. It is possible that the names that were given were not accurately recounted or that they were off-brand suppliers that are not easily traceable.

Table 15: The herbicides that were listed during the household interviews.

Name of Herbicide	Number of times listed	Company	Country	Active Ingredient
Altrazine and Mesotrione Products				
Kolopa	1	Unknown	Unknown	Atrazine, Mesotrione, Nicosulfuron
Maize Weed Killer	2	Exgenta Hong Kong Ltd.	Hong Kong	Atrazine, Cyanazine
Suceed	3	Shandong Binnong Technology Co., Ltd	China	Altrazine, Mesotrione, Nicosulfuron
Uknown Mesotrione	4	Shenzhen Chem Tech Industry Co., Ltd	Unknown	Mesotrione
Cypermethrin Products				
Unknown Cypermethrin	1	Unknown	Unknown	Cypermethrin
Glyphosate Products				
Glyforce	1	Fine Crops Agro Care Pvt. Ltd	India	Glyphosate
Glyphocure	1	Cure Chem India	India	Glyphosate
Glyphosnow	1	Snow International Trading Limited	China	Glyphosate
Glytech	1	Unknown	Unknown	Glyphosate
Piranha	1	Farm-Ag International	South Africa	Glyphosate
Razor	1	Nufarm	USA	Glyphosate
Roundup	2	Bayer	Gemany	Glyphosate
Scorpion	1	Monsanto/Bayer	Germany	Glyphosate
Springbok 360 SL	1	Arysta LifeScience	India	Glyphosate
Unknown Glypohsate	24	Unknown	Unknown	Glyphosate
Other Products				
Pantera	1	Arysta LifeScience	South Africa	Quizalofop-P-tefuryl
Silver snow	1	Unknown	Unknown	Metolachlor
Stellar Star	3	BASF	Germany	Topramezone (pyrazolone), Dicamba (benzoic acid compound)
Uknown Paraquat	1	Unknown	Unknown	Paraquat

5.4.2. Cost and accessibility of herbicides

Households acquired herbicides primarily from retailers and agro-dealers within the community, which were the sources of 42% of herbicide products (=73). Households paid between 60 ZMW – 320 ZMW (4.38 EUR – 23.36 EUR) for a liter of herbicides with an arithmetic mean of 112 ZMW (SD = 69.85). Some herbicide products were unable to be included in the calculations because the amount purchased was unknown to the respondent or they had received an already mixed and diluted sprayer-full of the herbicide product, from which the quantity of the herbicide was unknown. Additionally, nine households received herbicides through the FISP in the form of membership fees and three households were given herbicides for free from a family member, or neighbor. Civil society/non-governmental organizations (NGO's) were the second most prominent source for herbicides (18%). Out-grower schemes (i.e., NWK, Continental, etc.) also provided herbicides to respondents, in addition to farmer's groups and camp officers in the community.

Households viewed herbicides to be quite costly and described the cost of herbicides of be increasing over time. Herbicides were considered to be ‘expensive’ or ‘very expensive’ by 69% of the HoHs (n=159) and 45% explained that the cost had increased over the last five years. Some uncertainty regarding the topic arose as 23% of the respondents did not know if there had been a change in price and 19% perceived the cost to be the same over time. However, some respondents did think of herbicides as being cheap (7%) and 13% saw a decrease in the cost of herbicides over time. Moreover, herbicides were said to be easily found by 61% of respondents with 69% describing the access to herbicides as being ‘easier’ or ‘much easier’ to find than in the previous five years.

5.4.3. Herbicide adoption

The longest use of an herbicide product was for 15 years, however 45 out of the 73 listed herbicide products have been used for a maximum of only two years (Figure 11). Similarly, 56% of the households (f=55) began using herbicides between one and two years prior to the study and 91% five years prior. Both the length in time of herbicide usage, and the number of households adopting herbicides, increased within a five-year period showing that not only new households were adopting herbicides but also households already using herbicides were adopting multiple products.

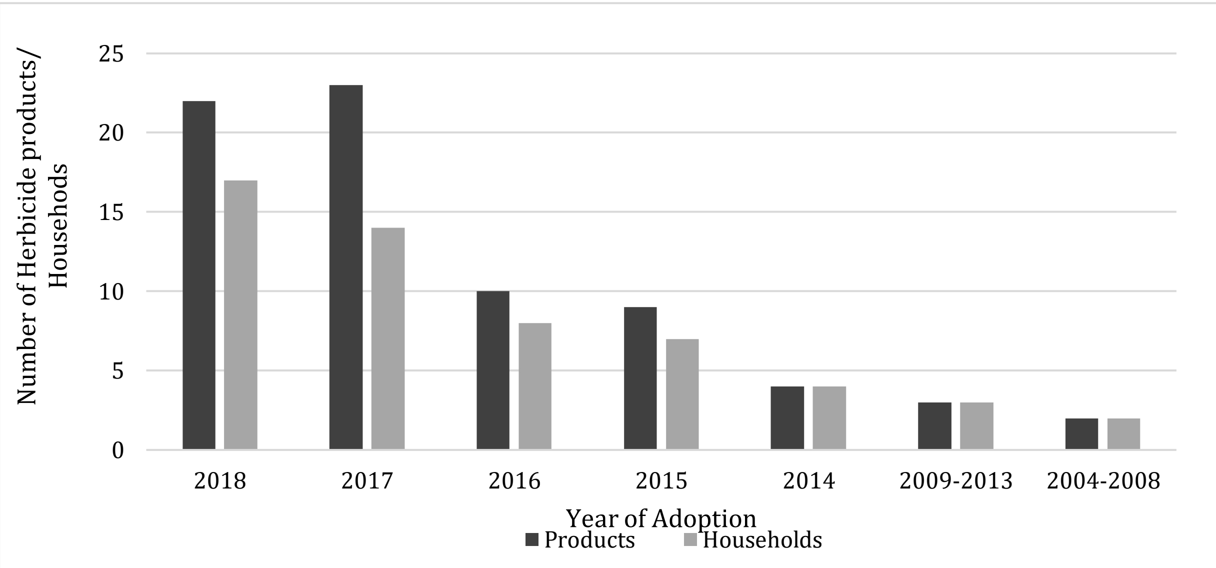

Figure 11: The year in which households first adopted herbicides and the year in which each herbicide product was first adopted (f=55).

Households demonstrated a high interest in herbicides with nearly half of the HoHs strongly agreeing with wanting to start using herbicides, or include more herbicides, into future agricultural practices (Table 16). Cumulatively 62% of households were interested in using herbicides consisting of 61% of the households who had not used herbicides before (f=104). 15% of households were highly opposed to the use of herbicides. Concerns about the overall health and vitality of the farm including crop, animal and soil health were mentioned by 15 respondents (Table 17). The topic of soil fertility was mentioned throughout the study mainly in regard to the loss of soil organic matter from weeds and soil erosion that may result from herbicide usage. Furthermore, four households explicitly stated that they did not use herbicides because of the effect it might have on edible weeds. The primary reason for not using herbicides, however, was due to financial reasons (herbicides being viewed as expensive or not affordable to households), which were listed by 60% of households that were not using herbicides. Additional reasons for not using herbicides were not needing them, health concerns for the household members and not having sufficient knowledge about herbicides.

Table 16: The interest in future adoption rates of herbicides as described by the HoH.

I would like to adopt (adopt more) herbicides in the future into my farming practices.						
Response	**Total Households**	**%**	**Households Using Herbicides**	**%**	**Households Not Using Herbicides**	**%**
Strongly Disagree	27	17%	11	20%	16	15%
Disagree	6	4%	1	2%	5	5%
Neutral	28	18%	9	16%	19	18%
Agree	20	13%	1	2%	19	18%
Strongly Agree	78	49%	33	60%	45	43%
Total	159	100%	55	100%	104	100%

Table 17: The reasons for not using herbicides as listed by the HoH (f=104). Multiple answers were possible.

Reasons for not using herbicides	**Households**	**%**
Financial Constraints	62	60%
Lack of Knowledge	17	16%
Not Needed	14	13%
Worried about overall farm health (crops, soil fertility, etc.)	15	14%
Concerns for other plants including edible weeds	5	5%
Not accessible/available	2	2%
Health Concerns	1	1%

5.4.4. Herbicide application measures

Safety concerns arose during the interviews among respondents in regard to herbicide implementation. In general, respondents believed that herbicides were harmful to the health of those that are applying them in the fields (Table 18). Around 58% of respondents, including both the HoH and the PRF, perceived herbicides to be harmful or very harmful. It was also believed that herbicides had no effect on one's health by 16% of the respondents and nearly a quarter of the respondents were unsure about the possible health consequences of using herbicides. Only 3% believed the herbicides to be beneficial to one's health. The belief that herbicides were beneficial resulted from the notion that the herbicides would result in better yields, and therefore more food for the pesticide applicator.

Table 18: The perceived health implications of herbicide application from both the HoH and the PRF.

Perception of Health Effects from Herbicide Usage	**Total Respondents**	**Percentage of Respondents** *n=270*
Very Harmful	121	45%
Harmful	34	13%
No Effect	43	16%
Beneficial	1	0%
Very Beneficial	7	3%
I don't know	64	24%

Cumulatively, 89% of the HoHs and PRFs believed that using some sort of protection is important when it comes to applying herbicides. Even though there is a general concern for safety amongst households, safety procedures for application, storage and clean up were not always followed. During the household interviews, the HoH was asked to list and describe all of the safety procedures that is followed by the pesticide applicator during the preparation, application and storage of the pesticides (Table 19). After which, the research assistant would prompt any missing procedures like washing hands and asking for details about the storage of the pesticide.

Clean up after use was the most commonly used safety procedure for the application of pesticides. Hand washing after application was listed by 89% of the households and 80% listed that the appliers changed their clothing. In regard to the hand washing, it is uncertain whether soap was used or not. The use of protective clothing is lower where only 65% of the pesticide appliers wore boots and 60% wore gloves. Less than half of the respondents said that the appliers wore overalls, long pants or long-sleeved shirts. Masks were worn by only 32% of appliers and eye protection by only 25%. The protective clothing used, however, was not always official protective gear. It was mentioned at least six times during the interviews that either the gloves or the masks were something that was fabricated from home materials.

One farmer in Chadiza used a mask that he had fashioned using mosquito net and plastic bags. Households also mentioned using plastic bags as gloves during pesticide application. Many of the respondents expressed a desire to use more protective clothing like gloves and masks but were unable to afford them. Outgrower schemes, like NWK, were often mentioned as sources for masks in particular.

The storage for herbicides and agrochemicals was problematic for a lot of households in the study. Over 60% of households made sure to store the pesticides out of reach for children but only 20 – 30% stored them away from food or out of the sun. In one household, bags of fertilizer were cut open inside the home where the respondent sat on a heap of urea as he answered questions from the interview. Households did not always have additional storage space outside of their living quarters making it difficult to store pesticides away from people, animals and food.

Table 19: The safety procedures followed by the pesticide applier as described by the HoH (f=55).

Safety Procedure		Applied	Not Applied	Unknown
Use of Protective Clothing	Gloves	60%	31%	9%
	Overalls	43%	48%	9%
	Boots	65%	27%	9%
	Eye Protection	25%	67%	9%
	Mask	32%	59%	9%
	Long Pants	41%	51%	9%
	Long Shirt	39%	53%	9%
Storage	Away from Food	31%	60%	9%
	Out of Reach from Children	63%	28%	9%
	Out of the Sun	20%	71%	9%
Cleaning Up	Hand Washing	89%	2%	9%
	Changing Clothes	80%	15%	9%

There are no official disposal sites for agrochemicals in Zambia, which is why nearly 70% of households using herbicides either threw the bottles away in the toilets or burned them. Other disposal methods included burying or throwing the containers into a bush or field. These two methods accounted for 23% of the disposal methods listed in the household interviews. Even more alarming is the repurposing of pesticide bottles. One farmer in Sinazongwe mentioned that he used the bottles as buoys for his fishing net. However, agrochemical bottles were more often repurposed for storing things including food items like salt and pumpkin seeds. Bottles were listed as being repurposed by only 2% of households, however, even when they were not listed as being repurposed, some farmers mentioned that they intentionally left the bottles in the open (throwing them in fields, bushes, etc.) so that they might be discovered by others to use. Children in the villages are particularly inclined to collect bottles to bring home for use. The households that were uncertain about the disposal method either did not apply the pesticides themselves or received the pesticides from an unofficial source (friend, neighbor, etc.) and therefore, never had a container to dispose of.

6. Discussion

6.1. Challenges and limitations of the study

Like with any quantitative interview, the study was subject to informant bias. The majority of the data collected from this study was provided through household interviews, and therefore the accuracy of the data is reliant upon the accuracy of the information provided by the respondents. Several measures were taken in order to ensure a higher degree of accuracy including translator training and survey questions designed to affirm answers to prior questions.

Additional bias can be found in the selection procedure of household respondents. As discussed in section 4.3.1, only the households that were accessible and known to the camp officer were able to be surveyed. The camp officers often described the jurisdiction of the camp to be much larger than they were capable of efficiently managing. Although respondents were randomly selected, households unaffiliated with the camp officers and community groups are not adequately represented by this study.

Due to time constraints for the entire study, the time available to collect edible weeds was limited. Only one or two field walks could be made within each camp over the course of a one-week timeframe. The short time period meant that the sought-after plants were not always available or in the optimal growth stage for identification.

Additionally, due to the overlapping of local names within and across communities it is possible that some species could be over or underrepresented. For example, *H. cannabinus* was identified under the local name Lumanda in the Eastern Province. This local name has been used to reference *H. cannabinus* as well as other *Hibiscus* species throughout Zambia that are known, cultivated or wild growing edible plants. (Vernon, 1983; Nyirenda, 2007; Mofya-Mukuka & Simoloka, 2015). Specifically, in the paper by Mofya-Mukuka & Simoloka, 2015, Lumanda was the local name used to reference *Hibiscus meeusei* in the

Eastern Province. This indicates the possibility that the edible weeds accounted for as *H. cannabinus* in this study may also include *H. meeusei*.

Finally, the study is limited in that it offers a visual for only a small sample in relation to the country of Zambia as a whole, and only in the view of a single snapshot. To fully understand trends, especially one relating to the usage of new technologies and the availability of wild food sources, multiple studies should be carried out over the course of years and to include a larger number of participants.

6.2. Edible weed significance

6.2.1. Diversity of edible weeds

The study illustrates that edible weeds are an important source of food in both the Eastern and Southern Province. All of the households consumed at least one edible weed species, although 96% of the households consumed multiple. A total of 22 plants were identified and consumed by respondents. These results coincide with two studies conducted throughout neighboring Zimbabwe where 19 (Maroyi, 2013) and 21 (Madamombe-Maduna et al., 2008) edible weeds were identified. The edible weeds found in this study overlap with 29% of the edible weeds in the study by Maroyi, 2013 and 37% of the edible weeds in the study by Madomombe-Maduna et al., 2008.

The plants identified in the present study however fall shy of the actual number of consumed species by households. At least three additional species were identified in the *Amaranthus* genus and one additional in the *Bidens* genus were unable to be counted separately in the study due to overlapping local names within communities. The 22 unidentified local names would also likely add to the list.

In both the Eastern and Southern Province *Amaranthus* sp., *C. olitorius*, and *Bidens* sp. were the most important edible weeds for food. *C. triloba* and *C. gynandra* are also relevant to be mentioned for both provinces. *H. cannabinus* was an important weed in the Eastern Province although it was only listed by one household in the Southern Province. It is likely that *H. cannabinus* is consumed by more households in both provinces. *H. cannabinus* was controversially discussed in interviews regarding its classification as a weed. Although it is a common arable weed in both the Eastern and Southern Province, many households considered

H. cannabinus as a cultivated horticultural plant that was intentionally grown in gardens or around homes. In this case, *H. cannabinus* may play a more important role in the diets of smallholder farmers, which was not able to be captured in this study where weeds were defined by spontaneous growth.

Although all of the important edible weed species, save *C. triloba*, were also found in the Zimbabwean studies, only *Biden pilosa* and *Cleome gynandra* were considered to be important in Zimbabwe (Maroyi, 2013; Madamombe-Maduna et al., 2008). *Amaranthus* sp. was by and large the most prominent edible weed in the Eastern and Southern Province of Zambia where it was used by 88% of households. In Zimbabwe, *Cleome gynandra* was the most important weed with *Amaranthus hybridus* cited as important by less than 40% of participants (Maroyi, 2013). Furthermore, *H. cannabinus* was only listed as a weed and not considered as a food source in Zimbabwe (Madamombe-Maduna et al., 2008).

Many of the edible weeds discovered in the present study are well-known across Africa as traditional leafy vegetables including *Amaranthus* sp., *C. olitorius*, *B. pilosa, C. triloba* and *C. gynandra* (Awohr, 2018; Uusiko et al, 2010; Sahrawat et al., 2020). In Zambia, these plants are considered to be wild growing traditional vegetables where few, like *Amaranthus* sp., are also sometimes cultivated (Catholic Relief Services, 2017). The study by Mofya-Muka & Simoloka, 2015 showed that households in Zambia have a high reliance on wild edible plants for food that were collected as forest products. However, there is limited information around the specific use of agricultural weeds as food in Zambia.

6.2.2. Edible weed collection

The current findings show that edible weed species are collected almost entirely from cultivated fields. Only 5% of households collected edible weeds outside of their own agricultural fields and 10% of households collected weeds from fallow fields in addition to cultivated fields. It is still unclear whether the edible weeds gathered outside of the respondent's fields are taken from wild areas or another individual's farmland. Since the question was designed with the focus on the household's own property, it is possible that these plants are still collected from agricultural fields and not actually from wild areas.

Comparable with the botanical dietary paradox, Zambia has a high rate of deforestation losing over 250,000 ha per year (Vinya et al, 2011; Cruz-Garcia & Price, 2011). This level of deforestation ranks Zambia as one of the countries with the highest level of deforestation in SSA (Phiri et al, 2019). Agriculture is known to be one of the biggest drivers for the loss of forest coverage (Pelletier et al., 2020). The resulting loss of biodiversity could explain a possible relationship transition from forests to agricultural fields for wild foods. Even though edible weeds are collected from agricultural fields, households may, in addition, rely on forests for other wild foods like mushrooms, fruits and game meat (Mofya-Muka & Simoloka, 2015).

The collection of wild edible plants from cultivated areas is not special to Zambia. In addition to the Zimbabwean studies, a study conducted in Ethiopia found that around 20% of wild edible plants were gathered from cultivated fields (Madamombe-Maduna et al., 2008; Maroyi, 2013; Asfaw & Tadesse, 2001). Moreover, in South Africa, wild vegetables were described as being collected predominantly from agricultural fields (Bvenura & Afolayan, 2015).

All of the edible weeds in the study were used as leafy greens with only one plant, *C. anguria*, used additionally for its fruits. *C. anguria* was a minimally consumed weed (consumed by 5≥ households) in the context of this study. In contrast, *C. anguria* was discovered to be much more prominent in Zimbabwe where it was consumed by 88% of respondents. Fruits were more important features of edible weeds in Zimbabwe than in Zambia. In Zimbabwe fruits were collected from 19% of edible weeds (Maroyi, 2015). In the Eastern and Southern Provinces of Zambia, edible weeds are primarily used as a relish to eat alongside nshima making the leaves and the young stems the most important parts of the plants (Catholic Relief Services, 2017). Collection of edible weeds while in the leafy, vegetative state could also make it easier to maintain the edible weeds to prevent competition with crops. In Mexico, farmers were found to monitor edible weed densities in crop fields and to remove them before they became a threat to the main crop (Madamombe-Maduna et al., 2008).

In addition to gathering wild edible weeds from fields, 14% of households cultivated them. These plants were grown on a small scale and mainly for self-consumption. Respondents showed a growing interest in cultivating edible weeds. The cultivation of edible weeds creates greater accessibility for households and also protects these plants from the threat of over-exploitation and habitat-loss (Dansi et al., 2009). There is little availability for seed outside of local sources (Mwai, 2007). The respondents relied on seeds that they saved either from plants growing within fields or from previously cultivated plants. Concomitant with studies conducted in South Africa (Maseko et al, 2018), edible weeds were often planted with broad-spectrum seeding in small household gardens and scattered around homes. One study in Zambia found that some edible weeds were cultivated during the dry season in order to ensure their availability year-round (Catholic Relief Services, 2017). In comparison to exotic vegetables, edible weeds require little in regard to inputs and can be grown in land that would otherwise be challenging for more demanding crops (Jansen van Rensberg et al., 2004).

6.2.3. Consumers of edible weeds

The amount of cultivated land, location of respondents by province and household size were the only significant factors that were discovered to influence edible weed consumption. Due to the fact that edible weeds are predominantly collected from cultivated fields, it is reasonable that households with more cultivated land would have access to more diversified land, and in turn, a wider range of weed species. Cultivated land area varied from .25 ha to 11.6 ha per household within the study. It was found that a larger land area typically means more fields rather than larger fields. Each additional field creates additional habitat through field margins, edge effect and microclimate variation which could increase the accessibility of households to a wider range of edible weed species (Benton et al., 2003; Hardegree & Van Vactor, 2004).

Location was the most significant socio-economic factor which influenced edible weed consumption. Edible weeds were eaten significantly more frequently in the Southern Province compared to the Eastern Province, which could be a result of either differences in culture or climatic stress. Climate change has greatly affected Zambia as parts of the country are experiencing prolonged droughts and erratic weather patterns (IPC Analysis, 2019). The Southern Province has been especially affected by drought resulting in significant crop failure over the last five years (IPC Analysis, 2019). It is possible that edible weeds were consumed more frequently in the Southern Province out of necessity due to food shortages arising from climatic stress.

There was no significant difference between the provinces in regard to the number of edible weed species consumed. However, the data for this correlation is somewhat limited by the number of unidentified edible weeds and the number of *Amaranthus* sp. and *Bidens* sp. that were unable to be differentiated within their genus.

There was a negative correlation between household size and the diversity of edible weeds consumed. Studies related to household size and diets are somewhat mixed. Some studies have indicated that larger households tend to be more food insecure relating to the need to feed more people within the household (De Cock et al., 2013; Kabunga et al., 2014). Other studies have shown that they may actually be more secure from the diversified contributions that come with having additional household members (Nyaruwata, 2019; Maitra & Rao, 2015). The former theory seems to contradict the relationship of household size and edible weeds within the present study. If larger households are in fact more food insecure, one could imagine a higher reliance on edible weeds. Household size not only had no effect on the frequency of consumption, but larger households were found to eat a smaller variety of edible weed species.

It is unclear why there is a relationship between household size and edible weed diversity. One possible explanation could be in line with the second theory in which larger households are more food secure. Larger households may have access to enough different food sources that they can be selective to eat only the edible weeds that they prefer. Despite having more mouths to feed, a larger household could equate to having a larger labor force which may aid in more efficient farming practices, higher yields or diversified income from household members working outside of the farms (Nyaruwata, 2019; Maitra & Rao, 2015). As a result, larger household could rely on fewer edible weed species along with a higher diversity of foods that are self-produced and purchased (Jones et al., 2014).

Edible weeds were consumed regardless of age, gender, education and income. Throughout SSA, traditional vegetables are widely consumed yet have often been referred to as food for the poor (Maroyi, 2013; Maseko et al., 2018; Awohr, 2018). Wealthier households are understood to be able to purchase the food that they need whereas poorer, and often rural, households may rely more on collecting wild and semi-cultivated vegetables due to a lack of financial resources and insufficient crop yields (Awohr, 2018; Mulumbi, 2015).

Conversely, income did not have any effect on the consumption patterns of edible weeds amongst households within the study. Since the study was conducted amongst rural households it is important to note that there is a significant income gap between rural and urban Zambia. Over 80% or rural populations in Zambia fall below the international poverty line in contrast to 25% of urban populations (The World Bank, 2020). As demonstrated in the studies by Nyaruwata, 2019 and Gido et al., 2017, even among rural and low-income populations, income variation can be a prominent influential factor. The study conducted in Zimbabwe found that socio-economic factors, including income, played a significant role in the consumption of indigenous vegetables and edible weeds among smallholder farmers (Nyaruwata, 2019). Poverty rates amongst smallholder farmers in Zimbabwe are similar to Zambia yet, in comparison with the present study, the effects of income on edible weed usage were not (Zimbabwe National Statistics Agency, 2019). Edible weeds may very well play an important survival role for lower-income households, yet they are likely more than just survival food. As the study by Weinberger, 2007 suggests, indigenous vegetables are not only for the poor but are also gaining interest amongst wealthy households indicating that these foods are undervalued rather than underutilized.

6.2.4. Edible weeds beyond food

Edible weeds were often used for more than food. Households used 36% of the identified edible weed species as medicine, 73% as fodder and 7% to sell for income. The versatility of edible weeds is concomitant with a number of studies throughout SSA regarding wild edible plants and traditional leafy vegetables (Bharucha & Petty, 2010; Maroyi, 2014; Nyaruwata, 2019; Maseko et al., 2018; Cruz-Garcia & Price, 2012).

Fodder was the most important secondary use for edible weeds. Livestock in Zambia are dependent on crop residues and natural pastures which are in limited supply and often low in nutritive value (Simbaya, 2002). The use of edible weeds as additional fodder are likely beneficial contributors to this nutrition deficit. *Amaranthus* sp. was the most frequently listed edible weed used for fodder and has similarly been documented as a protein rich and highly nutritive forage/fodder for livestock (Achigan-Dako et al., 2014; Cruz-Garcia & Price, 2014; Peiretti, 2018). Though it is likely certain species of *Amaranthus* function better as fodder than others due to the presence of anti-nutritional factors which can affect the digestibility of nutrients (Alegbejo, 2014; Olorunnisomo, 2010). *Amaranthus* sp. however was not the only edible weed used for fodder. All but six minimally consumed edible weeds were used as fodder. The frequency of certain edible weed species used for fodder follows closely with the overall frequency of edible weed species for personal consumption. As a result, it is likely that the prominence of edible weeds species as fodder is related to accessibility rather than preference.

Amaranthus sp. and *Bidens* sp. were the most important weeds for medicine, primarily in treatment of anemia which correlates with the study by Mofya-Mukuka & Simoloka, 2015. Diets in Zambia are highly comprised of maize with little diversification from more nutrient dense foods like, meat, dairy, legumes and horticultural vegetables (Mwanamwenge & Harris, 2017; Mofya-Mukuka & Mofu, 2016). Consequently, levels of malnutrition are alarmingly high with rates of undernourishment estimated to be as high as 48% (Mofya-Mukuka & Mofu, 2016). Nutrient poor diets have resulted in high occurrences of anemia especially prevalent among women and children (Mofya-Mukuka & Mofu, 2016). Both *Amaranthus* sp. and *Bidens pilosa* contain high levels of Vitamin A, Vitamin C, Iron and Zinc which can help to treat anemia when eaten as a food and used as a medicine (Akubugwo, 2007; Mofya-Mukuka & Simoloka, 2015; Catholic Relief Services, 2017; Nyirenda et al., 2009). While other ailments were treated with edible weeds by households, anemia was the most important.

Income was the least important secondary use for edible weeds. Within the camps edible weeds were often viewed as a commodity that was freely accessibly to everyone and therefore there was little demand to purchase. Moreover, it was challenging for households to access markets where there is a demand for edible weeds, primarily in urban areas. In Lusaka, edible weeds like *Amaranthus* sp. were found to be sold in open markets and even supermarkets, most of which was grown locally in peri-urban areas (Nguni & Mwila, 2007). Market infrastructure for rural Zambia is limited. Many are reliant on, “briefcase buyers” and government buyback programs to sell their crops **(**Greenberg et al., 2015). These systems offer assurance for the purchase of high-demand crops (primarily hybrid-maize) but at often low prices or late and uncertain payment times (Greenberg et al., 2015). Furthermore, they incentivize farmers to grow only a handful of crops resulting in decreased crop diversity and little to no interest in the development of edible weeds beyond the use of subsistence (Mwanamwenge & Harris, 2015).

There is potential for edible weeds species to become a more substantial source of income in rural Zambia, however this would likely require changes in agricultural development strategies, market access and cultivation practices (Nguni & Mwila, 2007; Nyaruwata, 2019). Agricultural development and research across SSA have largely neglected African leafy vegetables and edible weeds, which makes it difficult to understand their economic potential (Maroyi, 2014; Shayanowako et al., 2021). Nevertheless, there is evidence that substantial income can be made (Pincus et al., 2019). Demand for edible weed species, like *Amaranthus* sp. and *C. gynandra*, has been document throughout SSA, especially for those with limited access to these plants (Senyolo et al., 2017; Pincus et al., 2019). Most notably in Kenya, demand currently exceeds the production capacity displaying an opportunity for investment and further commercialization of these plants (Pincus et al., 2019).

6.3. Edible weeds and food security

6.3.1. Consumption patterns of edible weeds

Edible weeds are consumed and collected at the highest rates from December until March. This timeframe is both when weeds are the most abundant and food has become scarce (Catholic Relief Services, 2017). In Zambia, the rainy season can begin as early as October and last until March or April (Hachigonta et al., 2008). The onset, duration and amount of rainfall during the rainy season is variable and increasingly erratic due to climate change (Jain, 2007). Some edible weed species can grow year-round but weeds are most abundant and easily found during periods of higher rainfall (Mofya & Simoloka, 2015; Catholic Relief Services, 2017).

The availability of edible weeds was an important factor affecting changes in household consumption. The most frequently cited reason for which households consumed fewer edible weeds than in the past was due to fewer edible weeds being available. Similarly, an increased abundance of edible weeds was cited as the second most important reason for increasing consumption, following food insecurity.

The perceived availability of edible weeds over the duration of the past five years from the study are evenly dispersed. Almost an equal number of respondents perceived edible weeds to be fewer in abundance, the same and greater in abundance. The ambiguity in the perception of edible weed availability could be due to regional differences as well as differences in species variation. According to a study in Benin, 24 species of traditional leafy vegetables were labeled as threatened citing habitat loss and unsustainable harvesting methods as contributing factors (Dansi et al, 2009). Similarly, differences in management practices for the exploitation of edible weeds could affect populations densities throughout Zambia. Climatic stress could be another factor. Although edible weeds are generally considered to be drought tolerant, population densities can still be affected with some species more affected by drought than others (Jansen Van Rensburg, 2007; Mavengahama et al., 2013; Maseko et al., 2018).

The varying perceived availabilities likely explain why almost an equal number of households were consuming more edible weeds and fewer compared to the past five years (respectively 27% and 33% of households). Around 24% of households consumed more of some species and fewer of others. Although this could be due to changes in availability of certain weeds species it could equally be due to preference. Some edible weeds are described to have a bitter taste and unpleasant to eat (Mavengahama, 2013). These less palatable plants are often considered as famine foods and only eaten out of necessity (Shackleton, 2009).

Comparable to the studies by Maroyi, 2013 and Shiva et al., 2009 edible weeds were often preserved by means of sun-drying to be saved for future food security. Edible weeds were preserved by 86% of households, of which, all but one household preserved edible weeds in order to ensure food for the future. *C. olitorius*, *Bidens* sp. and *C. gynandra* were the most frequently preserved species. *C. olitorius* and *C. gynandra* are primarily available in the rainy season, but through preservation can be consumed over a wider span of time (Mofya-Mukuka, 2015; Thovhogi et al., 2021). Although *Bidens* sp. can be found throughout the whole year it was preserved in order to better the taste (Mofya-Mukuka, 2015).

The majority of the edible weeds are preserved during the rainy season (Mofya-Mukuka, 2015) and as discovered in the present study, were consumed at the highest frequency from August to October. These months lead up to the start of the hunger season when food stocks have begun to dwindle (Mwanamwenge & Harris, 2017). Often households are unable to harvest and store enough to last the entire dry season (Hart, 2011).

6.3.2. The role of edible weeds in food security

A clear reliance on edible weeds for food, especially in times of food insecurity was found within this study. Not only was this statement explicitly agreed upon by 87% of households, but the importance of edible weeds as food is further evident from: the correspondence of edible weed availability with seasonal food insecurity, use patterns of edible weeds for food security measures (as described in section 6.3.1), and the perceived importance of edible weeds for food and nutrition.

The perceived level of household food security did not influence the consumption of edible weeds. However, there was a strong correlation between viewing edible weeds as important during food insecure times and consumption rates. Households that viewed edible weeds to be important amidst food insecurity consumed significantly more edible weeds, and a wider variety of species. Since the level of food security was based on household perception rather than quantitative measurements, households which have access to edible weeds may not feel insecure even if other foods are scarce. This point is enforced by the relationship between household maize yield and edible weed consumption. Households with lower yields of their staple crop (i.e., maize), consumed edible weeds at a higher frequency compared to those with higher yields.

Climatic shocks from seasonal variability, coupled with the high population growth rates and limited access to food, has created a significant challenge to ensure food security in Zambia (Sitko et al., 2011; Kabisa, et al., 2019; Chapoto, et al., 2018). Seasonal hunger consists of a low-supply and high-demand for crops like maize typically during the farming season when crops are not yet ready for harvest (Mwanamwenge & Harris, 2017) and, as found in this study, peaked from December until March concomitant with edible weed availability. The time frame of availability for edible weeds makes them an easy resource to supplement diets amid seasonal scarcities and famine.

Indigenous and wild vegetables have been well-documented throughout Africa as famine foods (Shackleton, 2009; Madamombe-Maduna et al., 2008; Mahklouf 2019; Maroyi, 2014). Furthermore, many of the edible weeds found in this study including, *Amaranthus hybridus, Bidens pilosa, C. olitorius* and *C. gynandra*, were documented as being important contributors for supplementing diets (Mofya-Mukuka & Simoloka, 2015; Maroyi, 2013). Similarly, diet supplementation was the cited by over half of the households within this study for eating edible weeds. Although food insecurity was a prominent factor for eating edible weeds, tradition and a preference for edible weeds were each nearly equally mentioned. Edibles weeds, though important for food security, were not only eaten for food security but were a preferred food by 46% of households. Likewise, a high demand and preference for these foods was found in South Africa, Ghana and Kenya (Asase & Kumordzie, 2019; Senyolo et al., 2014; Gotor & Irungu, 2010).

The popularity of African leafy vegetables has continued to grow in Kenya largely due to campaigns dedicated to increased awareness about their nutritional benefits (Mwema & Crewett, 2019). Within the present study edible weeds were viewed to be highly nutritious by over 80% of the households. Still, 17% of households viewed edible weeds to be of low-nutritional value or to have no nutritional value at all. This viewpoint likely comes from the negative stigma still associating edible weeds as food for the poor (Catholic Relief Services, 2017; Keatinge et al., 2015).

The edible weeds species discovered within this study are largely undisputed regarding in their potential to increase dietary nutrition (Achigan-Dako et al., 2014; Maryoi, 2013; -Shayanowako et al., 2021). The nutritional benefits, however, vary between species, regions and cooking/preparation methods (Uusiku et al., 2010). Edible weeds from the study were cooked predominantly by boiling. Some edible weed species like *Amaranths* sp. contain antinutrients which can inhibit the uptake of vital nutrients. The heat from cooking reduces the amount of antinutrients but also reduces the amount of nutrients as well (Mziray et al., 2001). Minerals, like iron and zinc are relatively unaffected by cooking whereas nutrients like b-carotene and, even more so, ascorbic acid are affected (Uusiku, 2010). The preservation of edible weeds through drying can cause additional losses of nutrients in which the antinutrients are relatively unaffected (Mutuli & Mbuge, 2018; Uusiku, 2010). Even so, edible weeds are often higher in nutritional compounds than exotic vegetables and play an important role for nutrition security (Uusiku, 2010; Shayanowako et al., 2021).

Some efforts have been made to acknowledge the nutritional value of prominent edible weed species like *Amaranthus* sp. and *B. pilosa* by the Ministry of Health and other organizations in Zambia (Nyirenda et al., 2009). These efforts are however small compared to the national drive for maize intensification and agrochemical adoption. The promotion of hybrid maize through FISP and the FRA was designed with the intention to increase food security but may in fact contribute to seasonal food insecurity. Incentivizing a handful of crops drives communities to grow the same crops creating seasonal gluts and shortages (Greenberg et al., 2015). Moreover, the loss of agricultural diversity from neglecting traditional foods, like edible weeds, creates a high risk for farmers amidst increasingly erratic climatic stress (Chonabayashi et al., 2020).

6.4. Trade-offs with herbicides

6.4.1. Herbicide trends

The study found a high interest in herbicides with a higher-than-expected adoption rate amongst households. One third of the households within the study used herbicides which is around 7x higher than was surveyed in the Eastern and Southern Provinces in 2015 (4%) and 2x higher than was surveyed in 2019 (14%) by the Rural Agricultural Livelihood Survey (RALS) (Chapoto & Zulu-Mbata, 2016; Chapoto & Subakanya, 2019).

Households had started using herbicides as early as 2004 but over 80% of households first adopted them after 2013. These findings correlate the studies by Haggblade et al., 2017a and Grabowski & Jayne, 2016 which describe increasing herbicide usage throughout SSA starting in 2010, and in Zambia specifically around 2014. The increased rates between the two RALS surveys as well as the adoption timeframe of households within the study indicates a clear growing trend in herbicide adoption (Chapoto & Zulu-Mbata, 2016; Chapoto & Subakanya, 2019). It is likely that this trend will continue with the high interest and willingness to adopt herbicides from both households who were already using herbicides as well as those who were not.

The biggest hurdle for herbicide adoption comes from cost. The cost of herbicides in SSA are generally believed to have substantially decreased over the last decade (Haggblade et al., 2017a). Conversely, this was not felt by nearly half of the households within this study who described increasing prices. One reason for this discretion could be that herbicides are typically more expensive in remote/rural areas compared to urban areas (Haggblade et al., 2017a). Herbicides costs can also be variable depending on the type of herbicide and where it is sourced (Tamru et al., 2017; Haggblade et al., 2017b). The costs of herbicides per liter of product were highly variable within the study. Furthermore, costs of herbicides may seem higher to smallholder famers compared to better-off commercial scale farmers (Grabowski & Jayne, 2016; Haggblade et al., 2021).

In addition to the cost of herbicides, awareness and availability are major drivers which influence adoption rates in SSA (Grabowski & Jayne, 2016; Tamru et al., 2017; Haggblade et al, 2017a). As discovered in the study, households typically viewed herbicides as easy to find and increasingly more available. Furthermore, herbicides have become highly advocated through the promotion of conservation farming. Conservation farming is a farming method designed to enhance and restore soil health utilizing three main principles: 1) Minimizing soil disturbance, 2) maintaining permanent soil coverage and 3) utilizing diversified crop rotations (Rodenburg et al., 2020; FAO, 2021). Minimized tillage practices in conservation agriculture have become associated with herbicides as a means to control the heightened weed pressure

(Grabowski & Jayne, 2016). In Zambia these efforts are promoted by the government (MoA), NGOs, and the Conservation Farming Unit (CFU). CFU in particular has been a major actor in increased herbicide sales throughout the country (Westengen et al., 2018).

6.4.2. Benefits and concerns

Households used herbicides primarily to manage weed pressure and more effectively remove weeds. Glyphosate, specifically, is well acknowledged across the globe as a highly effective and broad-spectrum weed management tool (Baylis, 2000). Glyphosate was also the most prominent herbicide that was used within the study. In addition to efficacy, reducing labor was also an important benefit for using herbicides.

Labor reduction with herbicides comes with huge time savings advantages and lessens the burden of arduous work (Gianessi & Williams, 2011). In Zambia, herbicides were discovered to save approximately 30 days of labor per hectare (Goeb, 2020). The time saved in weeding may help to better manage weed competition, thereby increasing crop yields and potentially income (Gianessi & Williams, 2011). Women and children stand to benefit the most from the reduced labor since they manage the majority of hand weeding in Zambia. Using herbicides offsets some of the labor onto men who are typically in charge of spraying pesticides (Nyanga et al., 2012). Less time spent in the fields could open up the opportunity for women and children to stay in school longer. Education levels are low amongst rural households in Zambia, yet women disproportionately spend fewer years in school than men (Nyanga et al., 2012).

Reducing labor can also save money from lowering the need for hired labor. Increasing wage rates are one of the factors attributed to increasing rates of herbicide adoption (Haggblade, 2017a). The benefits of labor reduction are, however, two-edged. While one side benefits from cheaper weed management, laborers reliant on work as weeders may lose opportunities, therefore finding themselves deeper in poverty (Bouwman et al., 2020). In the study by Bouman et al., 2020, herbicides were found to benefit the already better-off farmers at the expense of the poor and food insecure who could not find work. It is further argued that, in this case, herbicides may not only increase food insecurity but also widen inequality (Bouwman et al., 2020).

The usage of herbicides brings with it a number of challenges. First, the benefits of herbicides are achieved only if they are properly applied. Farmers may be compelled to try to save money when using herbicides by either buying fraudulent products and/or spraying overly diluted products (Haggblade et al., 2017b; Umar et al., 2012). This can be prevented with proper training and regulation of products in the markets, which brings additional challenges. As argued by Haggblade et al., 2017b, herbicide usage is growing beyond regulatory capacity in West Africa, the same which could be argued for Zambia.

Fraudulent pesticides are unregistered generic products or counterfeits (Haggblade et al., 2017b; Haggblade et al. 2019). Counterfeits can be very difficult to track without laboratory testing and research on the topic in Zambia is highly limited (Sarkar et al., 2021). Studies carried out in other parts of Africa have found high rates of counterfeiting which are likely also present throughout less researched areas (Sarkar et al., 2021; Haggblade et al. 2019; Ashour et al., 2016). Over 40% of the herbicide products found within the present study were unknown, while this does not necessarily indicate fraudulence it does leave room to question the quality of the products that are used.

Counterfeit products comprise mislabeled, diluted and entirely falsified products which can be hazardous to the health of those who use them and the environment (Haggblade, 2019; Sarkar et al., 2021). Furthermore, the use of diluted products may not only be ineffective at controlling weeds but may also accelerate herbicide resistance negatively impacting long-term weed control (Haggblade et al., 2019).

Diluting is also carried out intentionally by farmers who want to save money and apply herbicides to as much land as possible (Umar et al., 2013). This was the case in two studies conducted in Zambia where farmers applied approximately 15% of the recommended dosage on fields (Umar et al., 2011; Umar et al., 2012). Studies suggest that the adoption of adequate safety equipment and proper methods of usage are highly dependent on knowledge and training (Malambo et al., 2019; Andrade-Rivas & Rother, 2018). Increasing measures of training and teaching are also crucial to ensure proper dosing and safe handling of these chemicals in Zambia. It was discovered that 24% of households were unsure about potential risks in using herbicides, and although 89% believed it was important to use safety equipment none of the farmers followed all of the procedures needed for safe usage. Limited knowledge due to lack of training are commonly associated with the mishandling of pesticides (Malambo et al., 2019).

The Lack of training and knowledge are not the only factors hindering proper usage. Households often did not have access to or could not afford to use official safety gear. The households who did use official gear (namely masks) often mentioned receiving them through out-grower schemes. Low adoption of protective equipment was also documented in South Africa (Andrade-Rivas & Rother, 2018). The handling and preparation of herbicides without adequate safety equipment puts farmers and their families at risk for a number of serious health consequences (Kang et al., 2016). Furthermore, the increased incidence of health problems associated with pesticide exposure may come with additional financial costs from the treatment of these ailments and the associated loss of labor (Sheahan et al., 2017).

6.4.3. Effects on edible weed consumption

There was no correlation discovered between herbicide usage and edible weed consumption patterns. Herbicide adoption rates are still low and a relatively new development in Zambia. Being that majority of herbicides were adopted by households two years prior to the study, it is likely too soon for potential effects to be visible.

Future adoption rates could pose a greater threat to edible weeds due to the overlapping timeframe of herbicide application with edible weed collection, and the collection of edible weeds from fields that were treated with herbicides. Herbicides were found to be sprayed predominantly in January and December which corresponds to the peak times for edible weed collection. Moreover, edible weeds were collected from 72% of the cultivated fields that were sprayed with herbicides, which would seem to indicate that populations of weed species would be affected or entirely unavailable from these fields.

Although respondents often mentioned that it was not possible to eat weeds after spraying the fields, it was not made clear how they collected the weeds from the same fields that they use herbicides on. One possibility is spraying only portions of the fields while leaving some areas of the field untouched for edible weed collection. This method was implemented by three households within the study. One study in Mexico utilized a similar method leaving portions of fields untreated for future collection of weeds as forage or food (Vieyra-Odilon & Vibrans, 2001).

The concern for the future availability of edible weeds is further acknowledged by Zambian households. In the study conducted by Nyanga et al., 2012, women expressed worry for food security in the case of herbicides eliminating edible weeds during the growing season. This concern was also raised in the study by Ms. Schweizerhof where women expressed worry about potential losses of edible weeds to herbicides in the future.

7. Conclusion

The study examines the contribution of edible agricultural weeds as food, and as contributors to food security for smallholder farming households in the Eastern and Southern Provinces of Zambia. Furthermore, trends in herbicide adoption rates were analyzed in order to understand the potential effects on edible weed consumption.

Edible weeds were discovered to be important contributors to the diets of smallholder farmers in the Eastern and Southern Provinces of Zambia, especially during periods of heightened food insecurity. The most important of which, were *Amaranthus* sp., *Corchorus olitorius*, *Bidens* sp., *Ceratotheca triloba* and *Cleome gynandra*. Edible weeds were seldom only used for food but were additionally important for fodder, medicine, and nutrition. Furthermore, edible weeds were consumed by all of the respondents regardless of age, gender, income and education demonstrating their role in food culture beyond famine foods.

Many of the edible weeds discovered within this study have already been acknowledged for their contribution to food security under the terms of African Leafy Vegetables and Indigenous Vegetables. This study reinforces their importance in food security and narrows the spotlight to focus on those which are collected as weeds from agricultural fields. The distinction in collection sites is crucial to understand how the consumption of these plants may be affected by the growing trend of herbicide adoption in SSA.

Although herbicide adoption was relatively low, they were of high interest amongst respondents. Increasing herbicide adoption rates may bring opportunities to reduce labor and financial costs but only if they are implemented with proper training. Based on the results of this study, current regulations and safety measures are not adequately addressed, creating a high risk for environmental health and the health of those who use them. Training is critically needed to ensure farmers are aware of potential health consequences and how to protect themselves with usage. Moreover, the inadequate usage of herbicides may further exacerbate food insecurity by removing edible weeds as a prominent food source. There was no visible trend between herbicide usage and edible weed consumption yet, however, as herbicide rates are expected to increase, it is likely future consumption rates will be affected.

While edible weeds do not solve the issue of food security, they are important mitigators for ongoing insecurity. It is crucial that they be considered in the future adoption and training measures for any new agriculture technologies, and especially for herbicides.

8. Expected impact

The findings of this study reveal two major points of interest: the importance of agricultural edible weeds as food for smallholder farmers, and the lack of regulation, training and education on herbicides. Based on the significant role that edible weeds play for food security, policy makers, NGO's and advocates for conservation farming need to consider the consequences that herbicides may cause to this food source. In light of expected increases in herbicide use alternative means of preservation must be made in order to protect edible weed species. Support for the development of the necessary market infrastructure and resources for cultivating edible weeds species could be one solution. Another solution would be to increase awareness about the effects that herbicides may have on edible weed populations.

Increasing training for farmers on proper handling and application of herbicides is crucial. Herbicide companies as well as organizations advocating for their usage have a responsibility to make sure that the farmers they influence are trained and knowledgeable on how to use such hazardous substances. Without doing so, they are putting the lives of the farmers at risk along with serious environmental consequences. Furthermore, it is important that safety equipment be accessible in terms of availability and cost. One example could be allocating some of the agricultural budget could go toward subsidizing masks and gloves.

9. References

Achigan-Dako, E. G., Sogbohossou, O. E. D., Maundu, P. (2014). Current knowledge on Aaranthus spp.: research avenues for improved nutritional value and yield in leafy amaranths in sub-Saharan Africa. Euphytica. 197. 303-317.

Addis, G., Urga, K., & Dikasso, D. (2005). Ethnobotanical Study of Edible Wild Plants in Some Selected Districts of Ethiopia. Human Ecology, 33(1). 83-118.

Adedeji O.B. & Okocha R.O. (2012). Overview of Pesticide Toxicity in Fish. Advances in Environmental Biology 6(8). 2344-2351.

Alegbejo, J.O. (2013). Nutritional Value and Utilization of Amaranthus (Amaranthus spp.) – A Review. Bayero Journal of Pure and Applied Sciences. 6(1). 136-143.

Alemayehu, F., Bendevis, M., Jacobsen, S.E. (2014). The Potential for Utilizing the Seed Crop Amaranth (Amaranthus spp.) in East Africa as an Alternative Crop to Support Food Security and Climate Change Mitigation. Journal of Agronomy and Crop Science. 201.

Ayanlade, A., Radeny, M., Morton, J. F., Muchaba, T. (2018). Rainfall variability and drought characteristics in two agro-climatic zones: An assessment of climate change challenges in Africa. Science of the Total Environment. 630. 728-737.

Anakwue, R. (2019) Cardiotoxicity of Pesticides: Are Africans at Risk?. Cardiovascular Toxicology. 19. 95 – 104.

Andrade-Rivas, F. & Rother, H.A. (2015). Chemical exposure reduction: Factors impacting on South African herbicide sprayers' personal protective equipment compliance and high risk work practices. Environmental Research. 142. 34-45.

Ashour, M., Billings, L., Gilligan, D., Hoel, J.B. & Karachiwalla, N. (2016) Do beliefs about agricultural inputs counterfeiting correspond with actual rates of counterfeiting? Evidence from Uganda. IFPRI Discussion Paper 01552. Washington, DC: International Food Policy Research Institute.

Asase, A. & Kumordzie (2019). Availability, cost, and popularity of African leafy vegetables in Accra markets, Ghana. Economic Botany. 72(6).

Asfaw, Z. & Tadesse, M. (2001). Prospects for sustainable use and development of wild food plants in Ethiopia. Economic Botany. 55(1). 47-62.

Awohr, O. (2018) From lesser-known to super vegetables: the growing profile of African traditional leafy vegetables in promoting food security and wellness. Journal of the Science of Food and Agriculture. 98(10). 3609-3613.

Bacchetta, L., Visioli, F., Cappelli, G., Caruso, E., Martin, G., Nemeth, E., et al. (2016). A manifesto for the valorization of wild edible plants. Journal of Ethnopharmacology, 191, 180-187.

Baskauf, S., & Kirchoff, B. (2008). Digital plant images as specimens: Toward standards for photographing living plants. Vulpia, 7, 16-30.

Baylis, A.D. (2000). Why glyphosate is a global herbicide: strengths, weaknesses and prospects. Pest Management Science. 56(4). 299-308.

Benton, T.G., Vickery, J.A. & Wilson, J.D. (2003). Farmland biodiversity: is habitat heterogeneity the key?. Trends in Ecology & Evolution. 18(4). 182-188.

Bharucha, Z., & Pretty, J. (2010). The roles and values of wild foods in agricultural systems. Philosophical Transactions of the Royal Society B: Biological Sciences, 365 (1554), 2913-2926.

Bhat, S.A., Bhat W.F. & Bano, B. (2016) Spectroscopic evaluation of the interaction between pesticides and chickpea cystatin: comparative binding and toxicity analyses. Environmental Science: Processes & Impacts. 18. 872-881.

Borelli, T., Hunter, D., Powell, B., Ulian, T. (2020) Born to Eat Wild: An Integrated Conservation Approach to Secure Wild Food Plants for Food Security and Nutrion. Plants. 9(10). 1-37.

Bouwman, T.I., Andersson, J.A. & Giller, K.E. (2021). Herbicide Induced Hunger? Conservation Agriculture, *Ganyu* Labour and Rural Poverty in Central Malawi. The Journal of Development Studies. 57 (2). https://doi.org/10.1080/00220388.2020.1786062

Bvenura, C. & Afolayan, A.J. (2015). The role of wild vegetables in household food security in South Africa: A review. Food Research International. 76(4). 1001-1011.

Catholic Relief Services. (2017). Assessment on Availability of African Indigenous Leafy Vegetables in Malawi and Zambia. Retrieved from https://www.crs.org/sites/default/files/tools-research/assessment_on_availability_of_ailvs_in_malawi_and_zambia.pdf

Central Statistical Office. (2014a). 2010 Census of Population and Housing - Eastern Province Anylitical Report. Lusaka: Central Statistical Office.

Central Statistics Office. (2014b). 2010 Census of Population and Housing Southern Province Analytical Report. Lusaka: Central Statistical Office.

Central Statistics Office. (2012). Zambia 2010 Census of Population and Housing National Analytical Report. Lusaka: Central Statistical Office.

Chapoto, A., Chisanga, B., & Kabisa, M. (2018). Zambia Agriculture Status Report 2017. Lusaka: IAPRI.

Chapato, A. & Subakanya (2019). Rural Agricultural Livelihoods Survey - 2019 Survey Report. Lusaka: IAPRI.

Chapoto, A., & Zulu-Mbata, O. (2016). Rural Agricultural Livelihoods Survey - 2015 Survey Report. Lusaka: IAPRI.

Chivenge, P., Mabhaudhi, T., Modi, A. T., & Mafongoya, P. (2015). The Potential Role of Neglected and Underutilised Crop Species as Future Crops under Water Scarce Conditions in Sub-Saharan Africa. International journal of environmental research and public health, 12(6), 5685–5711. https://doi.org/10.3390/ijerph120605685

Chonabayashi, S. Jithitikulchai, T. & Qu, Y. (2020). Does agricultural diversification build economic resilience to drought and flood?. Evidence from poor households in Zambia. African Journal of Agricultural and Resource Economics. 15(1). 65-80.

Cruz-Garcia, G. S., & Price, L. L. (2011). Ethnobotanical investigation of 'wild' food plants used by rice farmers in Kalasin, Northeast Thailand. Journal of Ethnobiology and Ethnomedicine. 7(33).

Cruz-Garcia, G. S., & Price, L. L. (2012). Weeds as important vegetables for farmers. Ethnobotany of Wild Plants, 81 (4), 397-403.

Damalas, C.A & Eleftherohorinos, I.G. (Pesticide exposure, safety issues, and risk assessment indicators. (2011). International Journal of Environmental Research and Public Health. 8(5). 1402-1219.

Dansi A., Adjatin A., Adoukonou-Sagbadja H., Faladé V., Adomou A.C., Yedomonhan H., Akpagana K. & de Foucault, B. (2009). Traditional leafy vegetables in Benin: Folk nomenclature, species under threat and domestication. Acta Botanica Gallica. 156(2). 183-199.

Daramola, O.S., Adigun, J.A., Olorunmaiye, A. M. (2020) Challenges of weed management in rice for food security in Africa: A review. Agricultura Tropica et Subtropica. 53(3). 107-115.

Day, R., Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M.J.W., Colmenarez, Y., Corniani, N., Early, R., Godwin, J., Gomez, J., González-Moreno, P., Murphy, S., Oppong-Mensah, B., Phiri, N., Pratt, C., Silvestri, S., Witt, A. (2017). Fall Armyworm: Impacts and Implications for Africa. Outlooks on Pest Management. 28. 196-201.

De Cock, N., D'Haese, M., Vink, N., Rooyen, C., Staelens, L., Schonfeldt, H. & D'Haese, L. (2013). Food Security in Rural Areas of Limpopo Province, South Africa. Food Security. 5. 269–282.

Department of Energy Zambia. (2017). Environmental and Social Management Framework: Zambia Electricity Service Access Project. Retrieved from http://documents.worldbank.org/curated/en/439551494596125878/pdf/SFG3353-REVISED-EA- P162760-Box402909B-PUBLIC-Disclosed-5-16-2017.pdf

Duke, S. (2011) Why have no new herbicide modes of action appeared in recent years? Pesticide Management Science. 68. 505-512.

Dzerefos, C. M., Shackleton, C. M. and Scholes, M. C. (1995) 'Seed germination, nitrogen nutrition and water requirements of the edible herb Corchorus tridens L.', Economic Botany. 49(380).

Fanzo, J. (2012). The Nutrition Challenge in Sub-Saharan Africa. UNDP Africa Policy Notes (no. 2012-012). United Nations Development Programme, Regional Bureau for Africa.

FAO. Conservation agriculture FAO. Accessed 10/01/2021. http://www.fao.org/conservation-agriculture/en/.

FAO, IFAD, UNICEF, WFP & WHO. 2018. The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. Rome, FAO.

FAO, IFAD, UNICEF, WFP and WHO. 2020. The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Rome, FAO.

Flora Zambesiaca. Kew, UK. Kew Royal Botanic Gardens.

Fowler, D. (2007). Zambian Plants: Their Vernacular Names and Uses. Richmond, UK: Royal Botanical Gardens.

Gianessi L. P. (2013). The increasing importance of herbicides in worldwide crop production. Pest management science, 69(10). 1099–1105.

Gianessi, L. & Reigner, N. P. (2017) The Value of Herbicides in U.S. Crop Production. Weed Technology. 21(2). 559-566.

Gianessi, L. & Williams A. (2011) Overlooking the Obvious: The Opportunity for Herbicides in Africa. Outlooks on Pest Management. 22(5). 211-215.

Gliessman, S. R., Garcia, R. E., Amador, M. A., (1981). The ecological basis for the application of traditional agricultural technology in the management of tropical agro-ecosystems. Agro-Ecosystems. 7(3). 173-185.

Goeb. J. (2013). Conservation farming adoption and impact among first year adopters in central Zambia. IAPRI Working Paper No. 80. Lusaka, Zambia: Indaba Agricultural Policy Research Institute.

Gotor, E. & Irungu, C. (2010) The impact of Bioversity International's African Leafy Vegetables programme in Kenya. Impact Assessment and Project Appraisal. 28(1). 41-55.

Grabowski, P. & Jayne, T. (2016). Analyzing Trends in Herbicide Use in Sub-Saharan Africa. Food Security International Development Working Papers 245909. Michigan State University. Department of Agricultural, Food, and Resource Economics.

Green, J.M. (2016) The rise and future of glyphosate and glyphosate-resistant crops. Pest Management Science. 22(5). 1035-1029.

Greenberg, S., Davies, F. & Swanepoel, S. (2015). Which way forward for Zambia's smallholder farmers: Green Revolution input subsidies or agroecology? (ACB report).

Hachigonta, S., Reason, C.J.C. & Tadross, M. (2008). Theoretical and Applied Climatology. 91(1). 229-243.

Haggblade, S., Melinda S., Kergna, A., Theriault, V. & Assima, A. (2017b). Causes and consequences of increasing herbicide use in Mali. The European Journal of Development Research. 29. 648-674.

Haggblade, S., Minten, B., Pray, C., Reardon, T., & Zilberman, D. (2017a). The Herbicide Revolution in Developing Countries: Patterns, Causes, and Implications. European Journal of Development Research , 29 (3), 533-559.

Hasanuzzaman, M., Mohsin, S.M., Borhannuddin Bhuyan, M.H.M, Bhuiyan, T.F., Anee, T.I., Chowdhury, A.A. & Kamrun, N. (2020). Chapter 3 - Phytotoxicity, environmental and health hazards of herbicides: challenges and ways forward. Editor: Majeti Narasimha Vara Prasad. Agrochemicals Detection, Treatment and Remediation. Butterworth-Heinemann. 55-99.

Hardegree, S.P. & Van Vactor, S.S. (2004). Microclimatic Constraints and Revegetation Planning in a Variable Environment. Weed Technology. 18(1). 1213-1215.

Hart, T. (2011). The significance of African vegetables in ensuring food security for South Africa’s rural poor. Agriculture and Human Values. 28(3). 321- 333.

Hildreth, J., Hrabeta-Robinson, E., Applequist, W., Betz, J. & Miller J. (2007). Standard operating procedure for the collection and preparation of voucher plant specimens for use in the nutraceutical industry. Analytical and Bioanalytical Chemistry. 389. 13-17.

Hobbs, P.R., Sayre, K. & Gupta, R. (2008). The role of conservation agriculture in sustainable agriculture. Philosophical Transaction of the Royal Society B. 363. 543-555.

Hussain, M., Farooq, S., Merfield, C., & Jabran, K. (2018). Mechanical Weed Control. In K. Jabran, & B. S. Chauhan, Non-Chemical Weed Control. 133-155. Academic Press.

IAPRI. (1. 1 2019). IAPRI. Abgerufen am 4. 9 2019 von Indaba Agricultural Policy Research Institute - Centre of Agricultural Policy Excellence: http://www.iapri.org.zm

Integrated Food Security Phase Classification (IPC) (2019) Zambia faces acute food insecurity due to erratic and low rains. IPC Acute Food Insecurity Analysis. http://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1152117/

Jain, S. (2007). An Empirical Economic Assessment of Impacts of Climate Change on Agriculture in Zambia. Policy Research Working Paper; No. 4291. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/7478 License: CC BY 3.0 IGO.

Jansen van Rensberg, W.S., Venter, S.L., Netshiluvhi, T.R., van den Heever, E., Vorster, H.J. & de Ronde, J.A. (2004). Role of indigenous leafy vegetables in combating hunger and malnutrition. South African Journal of Botany. 70(1). 52-59.

Joala, R., Zamchiya, P., Ntauzai, C., Musole, P., & Katebe, C. (2016). Changing agro-food systems: The impact of big agro-investors on food rights - Case Studies from

Mozambique and Zambia. Retrieved from http://www.plaas.org.za/plaas-publication/book-agrofood-systems-joala

Jones, A.D., Shrinivas, A. & Bezner-Kerr, R. (2014). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. Food Policy. 46. 1-12.

Kabisa, M., Mulenga, B. P., & Chapoto, A. (2019). Zambia Agriculture Status Report 2019. Lusaka: Indapa Agricultural Policy Research Institute.

Kabunga, N., Dubois, T. & Qaim, M. (2014). Impact of tissue culture banana technology on farm household income and food security in Kenya. Food Policy. 45. 25–34.

Kang, A., Kang, J.S., Jagroop, K., Kaur, S. & Kaur, N. (2016). Herbicides are escalating severe public health problems but unavoidable for food security. International Journal of Medicine and Pharmaceutical Science. 6(4). 1-12.

Keatinge, J. D. H., Wang, J., Dinssa, F., Ebert, A. (2015). Indigenous vegetables worldwide: Their importance and future development. Acta Horticulturae

Knezevic, S.Z. & Datta, A. (2015) The critical period for weed control: revisiting data analysis. Weed Science. 63(1). 188-202.

Kotir, J. H. (2011). Climate change and variability in Sub-Saharan Africa: A review of current and future trends and impacts on agriculture and food security. Environment, Development and Sustainability. 13. 587-605.

Kruger, G.R., Johnson, W.G., Doohan, D.J. & Weller, S.C. (2012). Dose response of glyphosate and dicamba on tomato (Lycopersicon esculentum) injury. Weed Technology. 26. 256-260.

Lehman, R.M., Cambardella, C.A., Stott, D.E., Acosta-Martinez, V., Manter, D.K., Buyer, J.S., Maul, J.E., Smith, J.L., Collins, H.P., Halvorson, J.J., Kremer, R.J., Lundgren, J.G.,
Ducey, T.F., Jin, V.L. & Karlen, D.L. (2015) Understanding and Enhancing Soil Biological Health: The Solution for Reversing Soil Degradation. Sustainability. 7(1). 988-1027.

Madamombe-Maduna, I., Vibrans, H., & López-Mata, L. (2008). Diversity of coevolved weeds in smallholder maize fields of Mexico and Zimbabwe. Biodiversity and Conservation, 18, 1589–1610.

Mahklouf, M.H. (2019). Ethnobotanical study of edible wild plants in Libya. European Journal of Ecology. 5(2). 30-40.

Maitra, C. & Rao, P.D.S. (2015). Poverty–Food Security Nexus: Evidence from a Survey of Urban Slum Dwellers in Kolkata. World Development. 72. 308–325.

Malambo, M.J., Mukanga, M., Nyirenda, J., Kabamba, B. & Salati, R.K. (2019). Knowledge and practice of pesticides use among small holder farmers in Zambia. International Journal of Horticulture, Agriculture and Food Science. 3(4). 184-190.

Maroyi, A. (2013). Use of weeds as traditional vegetables in Shurugwi District, Zimbabwe. Journal of Ethnobiology and Ethnomedicine. 9(1). 60-70.

Maroyi, A. (2014). Not just minor wild edible forest products: Consumption of pteridophytes in sub-Saharan Africa. Journal of Ethnobiology and Ethnomedicine. 10(1). https://doi.org/10.1186/1746-4269-10-7.

Maseko, I., Mabhaudhi, T., Tesfay, S., Araya, H. T., Fessehazion, M., Du Plooy, C. P. (2018). African Leafy Vegetables: A Review of Status, Production and Utilization in South Africa. Sustainability. 10(1): 16.

Masso, C., Nziguheba, G., Mutegi, J., Galy-Lacaus, C., Wendt, J., Butterbach-Bahl, K., Wairegi, L., Datta, A. (2017), Soil Fertility Management in Sub-Saharan Africa. Sustainable Agriculture Reviews. 25. 205-231.

Mavengahama, S., McLachlan, M., & de Clercq, W. (2013). The role of wild vegetable species in household food security in maize based subsistence cropping systems. Food Security. 227-233.

MIR Plus. (2012) Evaluation de la qualité des pesticides commercialisés dans huit pays de l'espace CEDEAO. Abuja and Abidjan : ECOWAS and UEMOA.

Mofya-Mukuka, R., & Simoloka, A. (2015). Forest Resources fr Rural Household Food and Nutrition Security: The Case of Eastern Province of Zambia. IAPRI Working Papers. Downloaded from IAPRI: http://www.iapri.org.zm/research-reports/working-papers.

Mofya-Mukuka, R., & Mofu, M. (2016). The Status of Hunger and Malnutrition in Zambia: A Review of Methods and Indicators. Lusaka: IAPRI.

Moreau, D., Pointurier, O., Nicolardot, B., Viller, J., Colbach, N. (2020). In which cropping systems can residual weeds reduce nitrate leaching and soil erosion?. European Journal of Agronomy. 119.

Mulenga, B.P., Kabisa, M., Chapoto, A. & Muyobela, T. (2020). Zambia Agriculture Status Report 2020. Lusaka: IAPRI.

Mulumbi, M. (2015). Eat With Us: Insight into Household Food Habits in a Time of Food Price Volatility in Zambian Communities. IDS Bulletin, 46(6), 53–59. https://doi.org/10.1111/1759- 5436.1218.

Mwanamwenge, M., & Harris, J. (2017). Agriculture, Food Systems, Diets and Nutrition in Zambia. Discussion Paper: IIED/Hivos.

Mwema, C. & Crewett, W. (2019). Institutional analysis of rules governing trade in African Leafy Vegetables and implications for smallholder inclusion: Case of schools and restaurants in rural Kenya.

Myers, J.P., Antoniou, M.N., Blumberg, B., Carroll, L., Colborn, T., Everett, L.G., Hansen, M., Landrigan, P.J., Lanphear, B.P., Mesnage, R., Vandenberg, L.N., vom Saal, F.S., Welshons, W.V. & Benbrook, C.M. (2016). Concerns over use of glyphosate-based herbicides and risks associated with exposures: a consensus statement. Environmental Health. 15(19).

Mziray, T.S., Imungi, J.K. & Karuri E.G. (2001). Nutrient and antinutrient in contents of raw and cooked Amaranthus hybridus. Ecology of Food and Nutrition. 40(1). 53-65.

Nelemans, J.B., van Wijngaarden, R.P.A., Roessink, I. & Arts, G.H.P. (2017). Effects of the herbicide Metsulfuron-Methyl on a plant community, including seed germination success in the F1 generations. Frontiers in Environmental Science. 5. https://doi.org/10.3389/fenvs.2017.00010

Nguni, D. & Mwila, G. (2007). Opportunities for increased production, utilization and income generation from African Leafy Vegetables in Zambia. AJFAND. 7(4).

Nyanga, P. H., Johnsen, F. H. & Kalinda, T. H. (2012). Gendered Impacts of Conservation Agriculture and Paradox of Herbicide Use among Smallholder Farmers. International Journal of Technology and Development Studies. 3(1).

Nyaruwata, Constance (2019). Contribution of Selected Indigenous Vegetables to Household Income and Food Availability in Wedza District of Zimbabwe. Acta Scientific Agriculture 3(3). 170-188.

Nyirenda, D., Musukwa, M. & Habulembe, R. (2007). The common Zabian foodstuff, ethnicity, preparation and nutrient composition of selected foods: research report. Lusaka: Republic of Zambia. [Web.] Retrieved from the Library of Congress. https://www.loc.gov/item/2019352348/.

Nyirenda, D. B., Musukwa, M., Habulembe, R., & Shindano, J. (2009). Zambia Food Composition Tables: 4th edition. Lusaka: National Food and Nutrition Commission.

Ojemaye, C.Y., Onwordi, C.T., Pampanin, D.M., Sydnes, M.O. & Petrik, L.F. (2020) Presence and risk assessment of herbicides in the marine environment of Camps Bay (Cape Town, South Africa). Science of the Total Environment. 738. 140346. 10.1016/j.scitotenv.2020.140346.

Olorunnisomo, O.A. (2010). Nutritive value of conserved maize, amaranth of maize-amaranth mixture as dry season fodder for growing West African Dwarf sheep. Livestock Research for Rural Development. 22(10). http://www.lrrd.org/lrrd22/10/olor22191.htm.

Ong, H. G., Young-Dong, K. (2017). The role of wild edible plants in household food security among transitioning hunger-gatherers: evidence from the Philippines. Food Security. 9. 11-24.

Peiretti, P.G. (2018). Amaranth in animal nutrition: A review. Livestock Research for Rural Development. 30(88). http://www.lrrd.org/lrrd30/5/peir30088.html

Pelletier, J., Ngoma, H., Mason, N.M. & Barret, C.B. (2020) Does smallholder maize intensification reduce deforestation? Evidence from Zambia. Global Environmental Change. 63. https://doi.org/10.1016/j.gloenvcha.2020.102127

Penagos, D. I., Magallanes, R., Valle, J., Cisneros, J., Martínez, A. M., Goulson, D., Chapman, J. W., Caballero P., Cave, R. D. &Williams, T. (2003). Effect of weeds on insect pests of maize and their natural enemies in Southern Mexico. International Journal of Pest Management. 49(2). 155-161.

Phiri, D., Morgenroth, J. & Xu, C. (2019) Four decades of land cover and forest connectivity study in Zambia – An object-based image analysis approach. International Journal of Applied Earth Observation and Geoinformation. 79. 97-109.

Phiri, L., (2016) CC BY-SA 4.0. https://commons.wikimedia.org/w/index.php?curid=52282421

Pincus, L., Croft, M., Roothaert, R. & DuBois, T. (2019). African Leafy Vegetable Seed Production as an Income Generating Opportunity for Women in Western Kenya.2019 Sixth International Conference, September 23-26, 2019, Abuja, Nigeria 295686, African Association of Agricultural Economists (AAAE).

Qi, Y., Li, J., Guan, X., Yan, B., Fu, G., He, J., Du, L., Zhao, C. & Zhang, D. (2020). Effects of herbicides on non-target plant species diversity and the community composition of fallow fields in northern China. Scientific Reports. 10: 9967.

Rapoport, E.H., Raffaele, E., Ghermandi, L., & Margutti, L. (1995). Edible weeds: A scarcely used resource. Bulletin of the Ecological Society of America. 76. 163-166.

Rawls, W.J., Pachepsky, P.A., Ritchie, J.C., Sobecki, T.M., Bloodworth, H. (2003). Effect of soil organic carbon on soil water retention. Geoderma. 116(1-2). 61-76.

Sahrawat, A., Rahul, S.N., Singh, S.K. & Patel, S. (2020). The potential benefits of weeds: A comparative study: A review. International Journal of Chemical Studies. 8(2). 148-154.

Sarkar, S., Dias Bernardes, J., Keeley, J., Möhrig & N., Jansen, k. (2021). The use of pesticides in developing countries and their impact on health and the right to food. European Union. Belgium. doi: 10.2861/28995

Senyolo, G.M., Wale, E. & Ortmann G.F. (2017). Consumers' Willingness-To-Pay for Underutilized Vegetable Crops: The Case of African Leafy Vegetables in South Africa. Journal of Human Ecology. 47(3). 219-227.

Shackleton, C., & Pasquini M. & Drescher, A. (2009). African Indigenous Vegetables in Urban Agriculture. Earthscan. London.

Sharma, S., Patel, M., Bhunch, M., Chatterjee, M. & Shrivastava, S. (2011). Regulatory Status of Traditional Medicines in Africa Region. International Journal of Research in Ayurveda and Pharmacy. 2(1). 103-110.

Shayanowako A.I.T, Morrissey O., Tanzi A., Muchuweti M., Mendiondo G.M., Mayes S., Modi A.T. & Mabhaudhi T. (2021). African Leafy Vegetables for Improved Human Nutrition and Food System Resilience in Southern Africa: A Scoping Review. Sustainability. 13(5):2896. https://doi.org/10.3390/su13052896

Sheahan, M., Barrett, C.B. & Goldvale, C. (2017). Human health and pesticide use in Sub-Saharan Africa. Agricultural Economics. 48. 27-41.

Shewamene, Z., Dune, T., & Smith, C. A. (2017). The use of traditional medicine in maternity care among African women in Africa and the diaspora: a systematic review. BMC complementary and alternative medicine, 17(1), 382.

Shava, S., O'Donoghue, R., Krasny, M.E. & Zazu C. (2009). Traditional food crops as a source of community resilience in Zimbabwe. Int J Afr Renais. 4. 31–48.

Simbaya, J. (2002). Availability and feeding quality characteristics of on-farm produced feed resources in the traditional small-holder sector in Zambia (IAEA-TECDOC--1294). International Atomic Energy Agency (IAEA).

Sisay B., Simiyu, J., Malusi P., Likhayo, P., Mendesil, E., Elibariki, N., Wakgari, M., Ayalew, G., Tefera, T. (2018). First report of the fall armyworm, Spodoptera frugiperda (Lepidoptera: Noctuidae), natural enemies from Africa. Journal of Applied Entomology. 142(8). 800-804.

Southon R. J., Fernandes O. A., Nascimento F. S., Sumner S. (2019). Social wasps are effective biocontrol agents of key lepidopteran crop pests. Proceedings of the Royal Society B. 286 (1914).

Swinton, S. & Van Deynze, B. (2017) Hoes to Herbicides: Economics of Evolving Weed Management in the United States. The European Journal of Development and Research. 29. 560-574.

Tamru, S. Minten, B., Bachewe, F. and Alemu, D. (2017) The rapid expansion of herbicide use in smallholder agriculture in Ethiopia: Evidence, drivers and implications. European Journal of Development Research. https://doi.org/10.1057/s41287-017-0076-5

The Angiosperm Phylogeny Group, Chase, M. W., Christenhusz, M. J. M., Fay, M. F., Byng, J. W., Judd, W. S., Soltis, D. E., Mabberley, D. J., Sennikov, A. N., Soltis, P. S., Stevens, P. F. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society, 181(1), 1–20.

The Plant List. (2010). Version 1. Published Online; http://www.theplantlist.org/ (accessed 1st January).

The World Bank. (2020). Poverty & Equity Brief Zambia. Retrieved March 30, 2021 from The World Bank: https://databank.worldbank.org/data/download/poverty/33EF03BB-9722-4AE2-ABC7-AA2972D68AFE/Global_POVEQ_ZMB.pdf

The World Bank. (2020). The World Bank in Zambia. Retrieved August 15, 2020 from The World Bank: https://www.worldbank.org/en/country/zambia/overview#:~:text=Zambia%20is%20experiencing%20a%20large,close%20to%20every%2025%20years.

Tian, X. & Yu, S. (2019). Crop yield gap and yield convergence in African countries. Food Security. 11. 1305-1319.

Timmons, F. L. (2005). A History of Weed Control in the United States and Canada. Weed Science , 53 (6), 748-761.

Trigo, E., Cap, E., Malach, V. & Villarreal, F. (2009) The case of zero-tillage technology in Argentina: International Food Policy Research Institute (IFPRI), IFPRI discussion papers.

Turner, N. J., Łuczaj, Ł. J., Migliorini, P., Pieroni, A., Dreon, A. L., Sacchetti, L., Enrica, P., Maurizio G. (2011) Edible and Tended Wild Plants, Traditional Ecological Knowledge and Agroecology, Critical Reviews in Plant Sciences, 30:1-2, 198-225.

Umar, B.B., Aune, J.B., Johnsen, F.H. & lungu, O.I. (2011). Options for improving smallholder conservation agriculture in Zambia. Journal of Agricultural Science. 3(3). 50-62.

Umar, B.B., Aune, J.B., Johnsen, F.H. & lungu, O.I. (2012). Are smallholder Zambian farmers Economists? A dual-analysis of farmers' expenditure in conservation and conventional agriculture systems. Journal of Agricultural Science. 36(8). 908-929.

Uusiku, N.P., Oelofse, A., Duodu, K.G., Bester, M.J. & Faber, M. (2010). Nutritional value of leafy vegetables of sub-Saharan Africa and their potential contribution to human health: A review. Journal of Food Composition and Analysis. 23. 499-509.

Vaitla B, Devereux S, Swan SH (2009) Seasonal Hunger: A Neglected Problem with Proven Solutions. PLOS Medicine 6(6): e1000101

Van Oost, K., Govers, G. & Desmet, P. (2000). Evaluating the effects of changes in landscape structure on soil erosion by water and tillage. Landscape Ecology. 15. 577-589.

Vats, S. (2015) Herbicides: History, Classification and Genetic Manipulation of Plants for Herbicide Resistance. Sustainable Agriculture Reviews. 15. 153-192.

Vieyra-Odilon, L., Vibrans, H. (2001). Weeds as crops: The Value of Maize Field Weeds in the Valley of Toluca, Mexico. Economic Botany 55(3), 426-443

Vinya, R., Syampungani, S., Kasumu, E.C., Monde, C. & Kasubika, R. (2011). Preliminary Study on the Drivers of Deforestation and Potential for REDD+ in Zambia. A consultancy report prepared for Forestry Department and FAO under the national UN-REDD+ Programme Ministry of Lands & Natural Resources. Lusaka, Zambia.

Vernon, R. (1983). Field Guide to Important Arable Weeds of Zambia. Chilanga, Zambia: Mount Makulu Central Research Station, Department of Agriculture.

Vorster, I.H.J., Jansen van Rensburg, W.S., & Venter, S.L. (2007). The importance of traditional leafy vegetables in South Africa. African Journal of Food Agriculture Nutrition and Development. 7(4). 1–13.

Weinberger, K. (2007). Are indigenous vegetables underutilized crops? Some evidence from Eastern Africa and South East Asia. Acta Hortic. 752. 29-34.

Wenhold, F., Faber, M. (2012). The nutritional status and strategies to address malnutrition. In Nutritional Value and Water Use of African Leafy Vegetables for Improved Livelihoods; WRC TT535/12; Oelofse, A., Van Averbeke, W., Eds.; Water Research Commission: Pretoria, South Africa.

Westengen, O.T., Nyanga, P., Chibamba, D., Guillen-Royo, M. & Banik., B. (2018). A climate for commerce: the political agronomy of conservation agriculture in Zambia.

WFO (2020): World Flora Online. Retrieved September 02, 2020, from http://www.worldfloraonline.org

Zimbabwe National Statistics Agency. (2019). Zimbabwe Poverty Report 2017. Harare: Zimbabwe National Statistics Agency.

Zingore, S., Mutegi, J. K., Agesa, B. L., Tamene, L., Kihara, J. (2015). Soil Degradation in sub-Saharan Africa and Crop Production Options for Soil Rehabilitation. Better Crops. 99. 24-26.

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10. Appendix

Identified Edible Weeds

Table 20: Identified edible weeds from the Eastern and Southern Province of Zambia.

* = Edible weeds consumed within the study

Scientific Name	Vernacular Names	ID Number/s
Acanthaceae		
Hygrophila sp. R. Br.	Duyu	22220
Amaranthaceae		
Aerva leucura Moq.*	Chombelo	22248
Alternanthera nodiflora R. Br.	Kasonkwa kankamene	22232
Alternanthera sessilis (L.) DC.*	Shamundonka	22235
Amaranthus graecizans L.*	Bonongwe, Green Bata, Bondwe	22249
Amaranthus graecizans L. subsp. *silvestris* (Vill.) Brenan*	Bonongwe, Green Bata, Bondwe	22250
Amaranthus c.f. *hybridus L.**	Mpemo yamubwa, Mpemo yamubwa red, Sunku	22212, 22225, 22237, 22242, 22223
Amaranthus sp. L. *	Red Bata, Kapikales, Bondwe, Bata, Chimowa, Bolyo	22251, 22252, 22253, 22254
Amaranthus spinosus L.*	Bonongwe, Bondwe	22256
Amaranthus viridis L. *	White bata, Bondwe, Bata	22257
Aristolochia heppii Merxm.	Tende	22226
Asteraceae		
Bidens pilosa L.*	Kabata, Big Leaf Kansoto,Big Leaf Nyasongwe, Siasipa	22258, 22259, 22260, 22228
Bidens schimperi Sch. Bip.*	Mbilizongwe, Little Leaf Kansoto, Little Leaf Nyasongwe, Hahipa	22261
*Bidens sp.**	Big Leaf Kansoto, Little Leaf Kansoto, Big Leaf Nyasongwe, Little Leaf Nyasongwe, Mphubu, kamphubu	
Galinsoga parviflora Cav.	Kadonkola mpoto	22284
Tithonia diversifolia (Hemsl.) A. Gray*	Kapusi pompi	22215
Cleomaceae		
Cleome gynandra L.*	Luni, Suntha, Shungwa, Luyuni	22265, 22266, 22267, 22268
Cleome hirta (Klotzsch) Oliv.	Kangaluni, Kumunakaluni	22269
Cleome monophylla L.*	Juniyuni, Kayunibwi, Kayuniyuni	22211, 22233

,

Table 7: Cont.

Scientific Name	Vernacular Names	ID Number/s
Commelinaceae		
Commelina benghalensis L.	Zomba, Nkwashe	22214
Commelina africana L. *var. lancispatha* C.B. Clarke*	Kwasia	22230
Convolvulaceae		
Ipomoea c.f. *obscura* (L.) Ker-Gawl. var. *obscura*	Kandambuwa	22279
Jacquemontia tamnifolia (L.) Griseb*	Matwi asulwe	22229
Cucurbitaceae		
Cucumis c.f. *anguria* L.*	Kakowakowa, Kasiili, Kasongo	22274, 22217, 22218, 22243
Cucumis metuliferus E. Mey. ex Naudin	Kafeyafeya, Kasilili	22238
Cyperaceae		
Cyperus digitatus Roxb. subsp *auricomus* (Sieb. ex Spreng.) Kük.	Nsekwa	22222
Euphorbiaceae		
Euphorbia c.f. *oatesii* Rolfe*	Kamwelele, Kadamwelele	22275, 22276
Fabaceae		
Crotalaria c.f. *cleomifolia* Welw. ex Bak.*	Zumba	22273
Senna obtusifolia (L.) Irwin & Barneby	Kanyemunyemu	22236
Ormocarpum kirkii S. Moore*	Phulu phulu	22280
Malvaceae		
Hibiscus cannabinus L.*	Jajaja, Lumanda, Kwankwe	22277, 22278
Hibiscus meeusei Exell	Mukokwa	22231
Hibiscus platycalyx Mast.	Hansembe	22234
Nyctaginaceae		
Boerhavia diffusa L.	Chinkhalamatongwe	22262
Onagraceae		
Ludwigia erecta (L.) Hara	Simuzigini	22239
Passifloraceae / Turneraceae		
Adenia gummifera (Harv.) Harms	Mulosi	22246
Adenia lobata (Jacq.) Engl.	Debelebe	22227
Adenia sp. Forssk.	Kakunde-kunde	22247
Tricliceras longepedunculatum (Mast.) R. Fernandes var. *longepedunculatum**	Katambara	22283

Table 7: Cont.

Scientific Name	Vernacular Names	ID Number/s
Pedaliaceae		
Ceratotheca c.f. *triloba* (Benth.) Hook. f.*	Katate, Gudu, Delele Gudu, Nkombu, Hahembe, Hatwembe, Lukomba, lumya	22263, 22216, 22244
Sesamum c.f. *angolense* Welw.*	Nyolonyolo, Sope	22281, 22282
Sesamum calycinum Welw.	Delele yamu mwezi	22286
Urochloa mosambicensis (Hackel) Dandy	Mpunga	22221
Portulacaceae		
Portulaca oleracea L.*	Msanze, Haii, Msanzo, Tellini, Twelana	22245
Solanaceae		
Solanum nigrum L.*	Ndulu	22219
Tiliaceae		
Corchorus olitorius L.*	Kaleyaleya, Kakokwa, Mbuyo, Buyu, Chelelwa, Tindingoma, Denje, Mtezi, Delele yamu munda	22270, 22271, 22272, 22213, 22240, 22241, 22285
Zygophyllaceae		
Tribulus sp. L.*	Kasongosongo	22224
Unknown edible weeds	Chikwachikwa, Chilunguthande, Kanjuchi, Katuku Lachenge, Kholowa Ntengo, Mphangwe, Msipu, Tambala	NA

Household Questionnaire

Questionnaire 1/17

QUESTIONNAIRE NUMBER	☐☐☐
HOUSEHOLD I.D.	☐☐☐
QUESTIONNAIRE CHECKED	☐

1. Introduction text

We are researchers from the German University of Hohenheim working together with the Indaba Agricultural Policy Research Institute (IAPRI) to study the roles of herbicides and edible weeds in food security for farmers in rural Zambia. We are hoping to get your expertise on the matter. We are conducting this research because we hope to use this information to influence the ministry of agriculture and NGO's to create better food accessibility for Zambians in the future. Although we cannot promise any direct benefits, a number of indirect benefits arise that can benefit you and your community as result of research projects like this. That is why we must take enough time to thoroughly collect the necessary data. The interview will take some time and we realize that you are very busy, however the knowledge that you could provide us with is really important. If you are willing to participate all of the information that you give during the interview will be kept strictly confidential. The data collected will be used for scientific purposes only and will not be given to any external individuals or organizations.

Would you be willing to participate in our project?

Participation in this survey is completely voluntary. If you decide not to participate there will not be any negative consequences. Please be aware that if you decide to participate, you may stop participating at any time and you may decide not to answer any specific question.

Thank you in advance for your participation!

* 1. I agree to participate in the research study. I understand the purpose and nature of this study and I am participating voluntarily.
- o Yes
- o No

* 2. I grant permission for the data generated from this survey to be used in anonymized form in the researcher's publications on this topic.
- o Yes
- o No

2. Household Information

Household I.D. ____ ____ ____

LOCATION OF THE HOUSEHOLD

(1) **Name of the Province** ______________________

(2) **Name of the District** ______________________

(3) **Name of the Village** ______________________

Detailed information of location (if necessary): ____
____

FIRST VISIT			*SECOND VISIT*		
(4)	**Date**	___ .___ . ___ *[dd/mm/yyyy)*	*(9)*	**Date**	___ .___ . ___ *[dd/mm/yyyy)*
(5)	**Response status**	___ *[Code A]*	*(10)*	**Response status**	___ *[Code A]*
(6)	**Name of interviewer**	______________________	*(11)*	**Name of interviewer**	______________________
(7)	**Name of translator**	______________________	*(12)*	**Name of translator**	______________________
(8)	**Language of the interview**	______________________	*(13)*	**Language of the interview**	______________________

(14) **Contact Information of household head:** ______________________________________

Code A

1 Interview completed	*4 Postponed*
2 Interview partially completed	*5 Refused*
3 No respondent at home	*90 Other (specify)*

1

3. Household Demographics (HEAD OF THE HOUSEHOLD)

Table 1: Demographics head of the household

HH Member I.D.	(15) Name	(16) Gender	(17) Age	(18) Religion	(19) Ethnic group	(20) Marital status	(21) Main occupation based on time spent in the last 12 months	(22) Years of completed schooling	(23) Member in group or organization? *Ask directly from Codes
	Full name	1 Male 2 Female	Number of years	A	B	C	D	Number of grades	List all: E
01									

(24) **How many members are in your household**?** ______ *[Number of people]*

****Definition of a household:** All people living in the household within in the last 6 months and children of household head not currently living in the household (e.g. boarding school)

Table 2: Household Demographics

Type I.D.	Age Groups	(25) Number of household members in each age group: Female	(26) Male
	Years	Number of people	Number of people
01	<7		
02	7-14		
03	15-20		
04	21-40		
05	41-60		
06	>60		

Codes 18-21: Household Demographics

Code A
1 Protestant
2 Catholic
3 Other Christian
4 Muslim
5 Traditionalists
6 No religion
90 Other (specify)

Code B
1 Chewa
2 Nsenga
3 Tumbuka
4 Ngoni
5 Kunda
6 Bemba
7 Tonga
8 Lozi
9 Bisa
10 Teka Leya
11 Luvale

Code C
1 Married – monogamous
2 Married – polygamous
3 Single
4 Divorced/separated
5 Widow/widower

Code D
1 Farming
2 Casual labour on another farm
3 Casual labour off-farm
4 Self-employed off-farm
5 Salaried employment (e.g. civil servant)
90 Other (specify)

Code E
1 Not a member in any
2 Woman group
3 Farmer group
4 Cooperative

4. Household Income (HEAD OF THE HOUSEHOLD)

(27) **How much of your total income in the last 12 months did you generate through …** *[Beans method, 20 beans]*

	Farm	Off-farm work (own business)	Wage/ salary	Others (e.g. remittances)
Amount of beans				

(28) **How much of income in the last 12 months did you generate on your farm through…** *[Beans method, 20 beans]*

	Crop production	Livestock production	Horticulture production	Aquaculture
Amount of beans				

2

5. Land Holding & Farm Description (HEAD OF THE HOUSEHOLD)

(29) **How many years have you been a farmer?** ___ *[Number of Years]* *95 I don't know* *99 Not applicable*

(30) **Do you practice Conservation Agriculture?** ___ *[1 Yes / 2 No]*

LAND HOLDING
**Specify the last season as the 2017/2018 farming season*

(31) **How much land did you cultivate in the previous season?** ______ *(in lima) or* ____ *(in ac) or* ____ *(in ha)*

(32) **How many lima/ac/ha of land did you leave fallow last season?** ______ *(in lima) or* ____ *(in ac) or* ____ *(in ha)*

(33) **How many lima/ac/ha of virgin land did you have?** ______ *(in lima) or* ____ *(in ac) or* ____ *(in ha)*

(34) **How many lima/ac/ha of land did you own last season?** ______ *(in lima) or* ____ *(in ac) or* ____ *(in ha)*

(35) **How many lima/ac/ha of land did you rent last season?** ______ *(in lima) or* ____ *(in ac) or* ____ *(in ha*

(36) **How many lima/ac/ha of land did you rent out last season?** ______ *(in lima) or* ____ *(in ac) or* ____ *(in ha)*

(37) **Did the household have access to communal land last season?** ______ *[1 Yes / 2 No]*

1 Lima = 0.25 ha or 0.62 ac *1 ac =0.4 ha or 1.6 lima* *1 ha = 2.47 ac or 4 lima*

LIVESTOCK

Table 3: Demographics Livestock

	TYPE I.D.		***01***	***02***	***03***	***04***	***05***	***06***	***07***
	Livestock		***Chicken***	***Ox***	***Cow***	***Goat***	***Pig***	***Sheep***	***Other (Specify)***
(38)	How many animals do you currently have?	*Number of animals*							

6. Farm plots (HEAD OF THE HOUSEHOLD)

(39) **How many crops did you have in the last season?**
(40) **For each crop: on how many plots did you plant it in the last season? (INCLUDE FALLOW PLOTS)**
(41) **Indicate the size of the plots (cross-checking with given cultivated land size) and the location from the homestead**
(42) **On which plots did you collect weeds in the last season?**

Sketch of the plots

Table 4: Please, describe your 10 largest plots beginning with the largest in the last season (2017/2018)

Plot I.D.	(43) Size of the plot	(44)	(45)	(46) Crops Grown	(47) Seed Inputs (main crop)	(48)	(49)	(50) Seed Type	(51) Seed input (other crop)	(52)	(53)	(54) Seed Type	(55) Fertilizer Inputs (basal)	(56)	(57)	(58) Fertilizer Input (top)	(59)	(60)
	in lima	in ac	in ha	List all: A Main crop first!	Qty #	Unit B	Price/Unit ZK	List all: C	Qty #	Unit B	Price/Unit ZK	List all: C	Qty #	Unit B	Price/Unit ZK	Qty #	Unit B	Price/Unit ZK
01																		
02																		
03																		
04																		
05																		
06																		
07																		
08																		
09																		
10																		

Plot I.D.	(61) Manure	(62)	(63)	(64) Herbicides Inputs	(65)	(66)	(67) Time of Application	(68) Fungicides Inputs	(69)	(70)	(71) Time of Application	(72) Insecticides Inputs	(73)	(74)	(75) Time of Application	(76) Output for main crop last season?	(77)
	Qty #	Unit B	Price/Unit ZK	Qty #	Unit B	Price/Unit ZK	List all: D	Qty #	Unit B	Price/Unit ZK	List all: D	Qty #	Unit B	Price/Unit ZK	List all: D	Qty #	Unit B
01																	
02																	
03																	
04																	
05																	
06																	
07																	
08																	
09																	
10																	

Codes 43-77: *Plots (table)*

Code A

1 Bambara nuts
2 Beans (Mixed)
3 Cashew Nut
4 Cassava
5 Coffee
6 Cotton
7 Cowpeas
8 Groundnut
9 Kenaf
10 Maize
11 Millet
12 Orange Corn
13 Paprika
14 Pigeon Peas
15 Popcorn
16 Irish potatoes
17 Rice
18 Sesame Seed
19 Sorghum
20 Soybean
21 Squash
22 Sugar Cane
23 Sunflower
24 Sweet Potato
25 Velvet Beans
26 Pumpkin leaves
27 Tobacco
28 Sun Hemp
29 Water Melon
30 Okra
31 Cucumber
32 Makola
33 Mundambi
34 Suntha
999 Fallow

Code B

1 90 kg bag
2 70 kg bag
3 50 kg bag
4 25 kg bag
5 20 kg bag
6 15 kg bag
7 10 kg bag
8 5 kg bag/ MEDA
9 20 l tin
10 90 kg bag unshelled
11 50 kg bag unshelled
12 25 kg bag unshelled
13 10 kg bag unshelled
14 Bunch
15 Kilogram
16 Litre
17 Handful
18 Bowl
19 Cup
20 ox cart
21 silo
22 individual heads
23 sprayer full
90 Other (specify)

Code C

1 Improved
2 Local
3 Saved seeds
90 Other (specify)
95 I don't know

Code D

1 January
2 February
3 March
4 April
5 May
6 June
7 July
8 August
9 September
10 October
11-Nov
12-Dec
95 I don't know

(78) **If no herbicides were used, why were they not used?** ____ *[Code A]*

(79) **If no herbicides were used, who made the decision not to use them?** ____ *[Code B]*

(80) **Did you take part in the Farmer Input Support Program or Electronic Voucher initiative (e-voucher)?** ______ *[1 Yes / 2 No]*

(81) **If yes, total amount spent:** ________________ZK

(82) **If yes, what kind of inputs did you use? How many?** ____ Seeds ____ Fertilizer *90 Other (specify) _______* *95 I don't know*

(83) **How much did your household spend on hired human labour (piece work) in the last season?** __________ *(in ZK)*

(84) **How much did your household spend on owned and/or rented machinery and draft animals in the last season?** __________ *(in ZK)*

Codes 78-79: Plots (not table)

Code A

1 Not affordable/Can't afford
2 Not available
3 No need
4 Worry about health
5 Worry about farm viability
6 Environmental concerns
7 Use of edible weeds
8 Not permitted (e.g. organic farming)
9 Lack of knowledge
10 Crop growth negatively affected
11 Decreased soil fertility
12 Not accessible
13 Concern for animal welfare
14 Concern for long-term effects
15 Concern about other plants
16 No money to buy

Code B

1 Head
2 Wife/ husband
3 Daughter/ son
4 Mother/ father
5 Sister/ brother
6 Grandchild
7 Grandparent
8 Step child
9 Step parent
10 Mother/ father-in-law
11 Sister/brother-in-law
12 Daughter/ son-in-law
13 House girl
14 Farm labourer
15 Friend
90 Other (specify)

7. Crops on the field (HEAD OF THE HOUSEHOLD)

Table 5: Please, list all the crops that your household has cultivated on the field in the last season (2017/2018)

	(85)	*(86)*	*(87)*	*(88)*	*(89)*	*(90)*	*(91)*	*(92)*	*(93)*
TYPE I.D.	**Crops Grown**	**What was your total output for the crop from the last season?**		**How much did you use for the consumption of the household?**		**How much did you sell?**		**Price/ Unit on average**	
	Crosscheck with (46), Code C	*Qty*	*Unit: D*	*Qty*	*Unit: D*	*Qty*	*Unit: D*	*ZK*	*Unit: D*
01									
02									
03									
04									
05									
06									
05									
06									
07									
08									
09									
10									

Codes 85-93: Crops on the fields

Code C

1 Bambara nuts
2 Beans (Mixed)
3 Cashew Nut
4 Cassava
5 Coffee
6 Cotton
7 Cowpeas
8 Groundnut
9 Kenaf
10 Maize
11 Millet
12 Orange Corn
13 Paprika
14 Pigeon Peas
15 Popcorn
16 Irish potatoes
17 Rice
18 Sesame Seed
19 Sorghum
20 Soybean
21 Squash
22 Sugar Cane
23 Sunflower
24 Sweet Potato
25 Velvet Beans
26 Pumpkin leaves
27 Tobacco
28 Sun Hemp
29 Water Melon
30 Okra
31 Cucumber
32 Makola
33 Mundambi
34 Suntha
999 Fallow

Code D

1 90 kg bag
2 70 kg bag
3 50 kg bag
4 25 kg bag
5 20 kg bag
6 15 kg bag
7 10 kg bag
8 5 kg bag/ MEDA
9 20 l tin
10 90 kg bag unshelled
11 50 kg bag unshelled
12 25 kg bag unshelled
13 10 kg bag unshelled
14 Bunch
15 Kilogram
16 Litre
17 Handful
18 Bowl
19 Cup
20 ox cart
21 silo
22 Individual heads
90 Other (specify)

8. Home Garden (HEAD OF THE HOUSEHOLD)

IF NO HOMEGARDEN, cont. (97)

Table 6: List all vegetables, legumes, fruits & other plants (incl. plants, which are maybe perceived as weeds by others) that your household cultivated in the last season 2017/18

TYPE I.D.	(94) Vegetables, legumes, fruits, other plants (incl. plants, which are maybe perceived as weeds by others)	(95) In which months did you harvest [TYPE]?	(96) How much of the total harvest was sold?
	A	List all: B	Percentage
01			
02			
03			
04			
05			
06			
07			
08			
09			
10			
11			
12			

Codes 94-95: Crops

Code A

1 Orange
2 Bananas
3 Pineapples
4 Guavas
5 Pawpaw
6 Avocado
7 Watermelon
8 Mangoes
9 Tangerines
10 Lemons
11 Grapefruits
12 Cabbage
13 Rape
14 Spinach
15 Tomato
16 Onion
17 Okra
19 Eggplant
20 Pumpkin
21 Chillies
22 Cauliflower
23 Carrots
24 Lettuce
25 Green beans
26 Green maize
27 Impwa
28 Pumpkin leaves
29 Sweet potato leaves
30 Cassava
31 Beans
32 Chinese cabbage
33 Sweet sorghum
34 Sugarcane
35 Mustard Greens
36 Green Pepper
37 Garlic
38 Tumeric
40 Amaranthus sp.
41 Makowa

Code B

1 January
2 February
3 March
4 April
5 May
6 June
7 July
8 August
9 September
10 October
11 November
12 December
95 I don't know
999 Not applicable

FARMING PRACTICES

(97) **Which land preparation methods did you use last season?** *List all: ________________________ [Code C]*

(98) **If more than one land preparation method, which land preparation method did you use for the majority of your land?** _________ *[Code C]*

Total number of plots: _____ *[Number]*

(99) **Did you grow cover crops?** ________ *[1 Yes / 2 No]*

(100) **If yes, on how many of your plots?** *[incl. fallow plots]* ________ *[Number]*

(101) **Did you practice crop rotation?** ________ *[1 Yes / 2 No]*

(102) **If yes, on how many of your plots?** *[incl. fallow plots]* ________ *[Number]*

(103) **Did you leave any crop residues on the plots?** ________ *[1 Yes / 2 No]*

(104) **If yes, on how many of your plots?** *[incl. fallow plots]* ________ *[Number]*

Codes 97 - 104: Farming Practices

Code C

1 Conventional Hand Hoeing
2 Planting Basins (potholes)
3 Zero Tillage (excluding Chitemene), Direct Drilling
4 Ploughing with a tractor
5 Plough with a draft animal
6 Ripping with a tractor
7 Ripping with a draft animal
8 Ridging with a tractor
9 Ridging with a draft animal
10 Contour farming/ Bunding
11 Did not till (broadcast seed)
12 Ridging with hand hoe

6

9. <u>Pesticides* Input</u> (HEAD OF THE HOUSEHOLD)

If no pesticides are used, cont. (116)

Table 7: Pesticide Input [herbicides, fungicides, insecticides (NO FERTILIZER)]

	(105)	*(106)*	*(107)*	*(108)*	*(109)*	*(110)*	*(111)*	*(112)*	*(113)*
TYPE I.D.	**What kind of pesticides did the household use in last year?**	**Type of pesticide**	**Where did the household get [TYPE] from?**	**For how long have you been using [TYPE]?**	**Why do you apply [TYPE]?**	**Which person in the household is responsible for [TYPE]? …decision on use?**	**…pre-paration?**	**…appli-cation?**	**From whom did your household receive consultations about the correct use and storage of [TYPE]?**
	Please list (Product/ trade name)) (95 I don't know)	*A*	*List all: B*	*Number of years*	***List all: C Try to capture all reasons!***	*D*	*D*	*D*	*List all: B*
01									
02									
03									
04									
05									
06									
07									
08									

(114) **How was/were the container(s) disposed?** ______ *[Code E]*

(115) **Explain the safety procedures you applied while preparing, using and storing the pesticides?** *(check all mentioned)*

Label container before use
Wearing…
- *Rubber gloves*
- *Overalls*
- *Gum boots/ stout shoes*
- *Eye protection*
- *Mask*
- *Long trousers*
- *Long sleeve shirt*

No eating/ smoking while handling
Wash hands/ take a bath after handling
Change clothes after handling
Storage away from food, fodder, medicine
Storage out of reach for children
Storage out of direct sunlight

<u>Codes 106-114:</u> Pesticides Input

Code A
1 Herbicide
2 Fungicide
3 Insecticide

Code B
1 Another farmer
2 Extension agent
3 Camp Officer
4 Neighbour
5 Relative
6 Friend
7 Civil society organization, NGO
8 Private pesticide company
9 Retailer/ Agro-dealer
10 Trader / middleman
11 Farmer group
12 Out-grower scheme
13 Research Organization
14 Chemist/Vet
15 FISP
16 Ministry of Agriculture
17 Employer
90 Other (specify)
95 I don't know
999 NA

Code C
1 Improvement of yields
2 Pest pressure – insects
3 Pest pressure – fungi
4 Pest pressure – other disease
5 Weed pressure
6 Farming practices (e.g. CA)
7 Interest
8 Saves labour force
9 Less burdensome labour
10 Saves time
11 Timeliness
12 Saves money
13 Research Purposes
14 Likes the effect on the leaves
15 Effective weed removal
16 Improves soil fertility
999 NA

Code D
1 Head
2 Wife/ husband
3 Daughter/ son
4 Mother/ father
5 Sister/ brother
6 Grandchild
7 Grandparent
8 Step child
9 Step parents
10 Mother/ father-in-law
11 Sister/brother-in-law
12 Daughter/ son-in-law
13 House girl
14 Farm labourer
15 Friend
16 Service provider
90 Other (specify)

Code E
1 In the toilet
2 Burning
3 Recycled
4 Disposed as hazardous waste
5 Burying
6 Throwing in bush/field
7 Repurposed
8 Thrown in trash pit
9 Not yet disposed
90 Other (specify)
95 I don't know

7

10. Weed* management (HEAD OF THE HOUSEHOLD)

* Definition of weed: plants, which grow on the field and aren't intentionally planted

Table 8: Weed management (Household members)

		TYPE I.D.											
		01	02	05	06	07	08	09	10	11	12	13	14
		< 7 years		7-14 years		15-20 years		21-40 years		41-60 years		> 60 years	
		Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
(116)	**How many people of [TYPE] were involved in weeding last season?**												
(117)	**How many weeks did [TYPE] spend on average for weeding?**												
(118)	**How many days/week did [TYPE] spend on average for weeding?**												
(119)	**How many hours/day did [TYPE] spend on average for weeding?**												

Table 8/1: Weed management (Rented labour/ piece work)

		TYPE I.D.							
		01	02	05	06	07	08	09	10
		< 7 years		7-14 years		15-20 years		> 20 years	
		Female	Male	Female	Male	Female	Male	Female	Make
(120)	**How many people of [TYPE] were involved in weeding last season?**								
(121)	**How many weeks did [TYPE] spend on average for weeding?**								
(122)	**How many days/week did [TYPE] spend on average for weeding?**								
(123)	**How many hours/day did [TYPE] spend on average for weeding?**								

(123/1) **Did the household use communal labor for weeding?** _____ *[1 Yes/ 2 No]*

(124) **What type of tool(s) for weeding did you use?** *[incl. sprayer]* *List all: __________ [Code A]*

(125) **Are there any benefits to having weeds on the field?** *List all: __________ [Code B]*

Codes 107-112: Weed management

Code A
1 Boom sprayer
2 Knapsack sprayer
3 Hoe
4 Harrow
5 (Ox-drawn) Plough
6 Cultivator
7 Hand weeding

Code B
1 Biodiversity
2 Pest suppression
3 Soil fertility
4 Weeds for consumption
5 Weeds for medicinal purposes
6 Weeds for fodder
7 Soil erosion
8 No benefit
9 Soil coverage

8

11. Knowledge Acquisition (HEAD OF THE HOUSEHOLD)

Table 9: Knowledge networks

Info TYPE I.D.	Type of information	(126) Do you have adequate information regarding [TYPE]?	(127) Where do you get information on [TYPE] from?	(128) Which of these sources is the most important?	(129) With how many people among your friends/relatives/neighbours did you talk about [TYPE] in the last 12 months?	(130) How many of these people are… Male	(131) Female	(132) Which gender do you perceive to be more knowledgeable on [TYPE]?
		1 Yes 2 No	List all: A **Try to capture all**	A **List only one**	Number of people (if 0 cont. (132))	Number of people	Number of people	1 Men 2 Women 3 Both
01	Herbicides							
02	Nutrition (e.g. cooking, healthy eating)							
03	Edible weeds							

Info TYPE I.D.	(133) Did you receive training on [TYPE]?	(134) From whom did you receive training?	(135) Please, rank the usefulness of the training.	(136) How many people asked you for information on [TYPE] in the last 12 months?	(137) How many of these people are… Male	(138) Female	(139) Who asks you for information on [TYPE]?
	1 Yes 2 No (cont. (136))	List all: A **Try to capture all**	(1 not useful at all - 5 very useful) **Emphasize possibility of numbers in between**	Number of people If 0, cont. to the next TYPE	Number of people	Number of people	List all: A **Try to capture all**
01							
02							
03							

Codes 127-139: Knowledge Acquisition

Code A

1 Government extension (Agriculture)	8 Parents/ Grandparents	15 Cooperative	22 Newspaper	29 Hospital/Health Centre
2 Government extension (Health)	9 Other relative (specify)	16 Company (e.g. Bayer, NWK)	23 Text messages (mobile phone)	30 Church
3 NGO/ NGO extension	10 Other farmer	17 Out grower scheme	24 Telephone call	31 CFU
4 Private extension	11 Women Group	18 Market place	25 TV	32 No source of information
5 Camp Officer	12 Farmer group	19 Traders / middleman	26 Internet	90 Other (specify)
6 Neighbour	13 Civil society organization	20 Agrochemical Dealer	27 Information sheet	
7 Friend	14 Farmer field school	21 Radio	28 Books	

12. Community Outreach Methods: Extension Agents (HEAD OF THE HOUSEHOLD)

Type I.D.	Type of extension	(140) How many visits or contacts with [TYPE] did you have during the last one year?	(141) Did they make any recommendations on herbicide use?
		Number of visits (If 0 cont. with next TYPE)	1 All of them recommended use 2 Some of them recommended use 3 Some recommended for, some against use 4 All recommended against 5 Didn't make any recommendations 99 Not applicable
01	Government Extension		
02	NGO Extension		
03	Private Extension		

13. Perceptions of herbicide use (HEAD OF THE HOUSEHOLD)

Table 10: Please rank each statement/question accordingly from 1 to 5 (using the hand to visualize the 5 categories):

EMPHASIZE POSSIBILITY OF NUMBERS IN BETWEEN

	Statements/Questions – Herbicides	*1*	*2*	*3*	*4*	*5*	*95 I don't know*	*99 Not applicable*
ACCESS								
(142)	How accessible are herbicides? (1 very difficult to find – 5 very easy to find)							
(143)	How do you perceive the price for herbicides? (1 very cheap – 5 very expensive)							
(144)	How accessible are herbicide compared to the last 5 years? (1 much more difficult to find –5 much easier to find) **3 the same**							
(145)	How do you perceive the price for herbicides compared to the last 5 years? (1 much cheaper – 5 much more expensive) **3 no change**							
AGRICULTURAL PRACTICES								
(146)	I would like to adopt (more) herbicides in the future into my farming practice (1 strongly disagree – 5 strongly agree)							
(147)	To achieve a high yield, how important are herbicides compared to other inputs? (1 not important at all – 5 very important)							
(148)	How do you perceive weed control compared to other challenges you face on the farm? (1 not problematic at all – 5 very problematic)							
(149)	How do herbicides affect soil fertility? (1 very harmful – 5 very beneficial) **3 no effect**							
(150)	How do herbicides affect the cultivation of legumes the year after application? (1 very harmful –5 very beneficial) **3 no effect**							
HEALTH								
(151)	How do herbicides affect one's health? (1 very harmful – 5 very beneficial) **3 no effect**							
(152)	Protection when applying herbicides is not necessary (1 strongly disagree – 5 strongly agree)							
ENVIRONMENT								
(153)	How do herbicides affect the surrounding environment of the farm? (1 very harmful – 5 very beneficial) **3 no effect**							
EDIBLE WEEDS								
(154)	How do edible weeds contribute to your household income? (1 no contribution at all – 5 high contribution)							
(155)	How do edible weeds affect food accessibility? (1 very harmful– 5 very beneficial) **3 no effect**							
(156)	Edible weeds are especially important in times of food scarcity (1 strongly disagree – 5 strongly agree)							
(157)	Edible weeds can be consumed even though insecticides are sprayed on the fields (1 strongly disagree – 5 strongly agree)							
(158)	How do you assess the nutritional value of edible weeds? (1 no value at all – 5 very high value)							
(159)	In general, the elderly have a greater knowledge about edible weeds than youth (1 strongly disagree – 5 strongly agree)							
(160)	How does fertilizer effect weed abundance? (1 greatly decreases – 5 greatly increases) **3 no effect**							
(161)	Fewer edible weeds are available as a result of herbicide usage (1 strongly disagree – 5 strongly agree)							

END OF THE PART FROM THE HOUSEHOLD HEAD

Is there anything you want to add?

14. Demographics for person responsible for food in the household (PERSON RESPONSIBLE FOR FOOD)

(162) **Is the person identical with the household head?** ___ *[1 Yes / 2 No] (if yes, cont. (173))*

Table 11: List person responsible for food in the household

Household member I.D.	(163) Name	(164) Gender	(165) Relationship with household head	(166) Age	(167) Religion	(168) Ethnic group	(169) Marital status	(170) Main occupation based on time spent in the last 12 months	(171) Years of completed schooling	(172) Member in group or organization? *Ask directly from Code
	Full name	1 Male 2 Female	A	Number of years	B	C	D	E	Number of grade	List all: F
02										

Codes 165-172: Information person responsible for food in the household

Code A	Code B	Code C	Code D	Code E	Code F
1 Head	1 Protestant	1 Chewa	1 Married – monogamous	1 Farming	1 Not a member in any
2 Wife/ husband	2 Catholic	2 Nsenga	2 Married – polygamous	2 Casual labour on another farm	2 Woman group
3 Daughter/ son	3 Other Christian	3 Tumbuka	3 Single	3 Casual labour off-farm	3 Farmer group
4 Mother/ father	4 Muslim	4 Ngoni	4 Divorced/separated	4 Self-employed off-farm	4 Cooperative
5 Sister/ brother	5 Traditionalists	5 Kunda	5 Widow/widower	5 Salaried employment (e.g. civil servant)	
6 Grandchild	6 No religion	6 Bemba		6 Student	
7 Grandparent	90 Other (specify)	7 Tonga			
8 Step child		8 Lozi			
9 Step parent		9 Bisa			
10 Mother/ father-in-law		10 Toka Leya			
11 Sister/brother-in-law		11 Luvale			
12 Daughter/ son-in-law					
13 House girl					
14 Farm labourers					
15 Friend					
16 Other extended family					

15. **Weeds** (PERSON RESPONSIBLE FOR FOOD)

Table 12: Weeds in the fields (1/2) ****Refer to the last 12 months***

- *If used only as fodder, stop with [186]*
- *If used only as medicine, stop with [186]*
- *If used as food, continue*

	(173)	(174)	(175)	(176)	(177)	(178)	(179)	(180)	(181)	(182)	(183)	(184)	(185)	(186)	(187)	(188)	(189)
TYPE I.D.	**Which were the most common weeds found on your field?**	**Actual use of [TYPE]**				**Parts used**		**Potential use of [TYPE]**				**If there are potential uses, why didn't you use [TYPE] in that way?**	**Did a household member collect [TYPE] in the last year?**	**Which hh member(s) was/were responsible for collection?**	**In which months did you collect [Type]?**	**In which months did you eat [TYPE] fresh?**	**How many days per month did you eat [TYPE] fresh?**
		Food	**Medicine (specify)**	**Fodder**	**Other (specify)**	**Food**	**Medicine**	**Food**	**Medicine (specify)**	**Fodder**	**Other (specify)**						
	A	*1 Yes 2 No 99 Not applicable*				*List all: B*		*1 Yes 2 No 99 Not applicable*				*List all: C*	*1 Yes 2 No 99 Not applicable*	*List all: D*	*List all: E*	*List all: E*	Number 1-31
01																	
02																	
03																	
04																	
05																	
06																	
07																	
08																	
09																	
10																	
11																	
12																	
13																	

Codes 173-189: Weeds (1/2)

Code A
1 Adenia gummifera
2 Adenia lobata
3 Adenia sp.
4 Aerva leucura
5 Alternanthera nodiflora
6 Alternanthera sessilis
7 Amaranthus graecizans
8 Amaranthus hybridus
9 Amaranthus sp.
10 Amaranthus spinosus
11 Amaranthus viridis
12 Aristolochia heppii
13 Bidens pilosa
14 Bidens schimperi
15 Bidens sp.
16 Boerhavia diffusa
17 Ceratotheca triloba
18 Cleome gynandra
19 Cleome hirta
20 Cleome monophylla
21 Commelina benghalensis
22 Commelina buchananii
23 Corchorus olitorius
24 Crotalaria cleomifolia
25 Cucumis anguria
26 Cucumis metuliferus
27 Cyperus auricomus
28 Euphorbia oatesii
29 Galinsoga parviflora
30 Hibiscus cannibinus
31 Hibiscus meeusei
32 Hibiscus platycalyx
33 Hygrophila sp.
34 Ipomoea obscura
35 Jacquemontia tammifolia
36 Ludwigia erecta
37 Ormocarpum kirkii
38 Portulaca oleracea
39 Senna obtusifolia
40 Sesamum angolense
41 Sesamum calycinum
42 Solanum nigrum
43 Tithonia diversifolia
44 Tribulus sp.
45 Tricliceras longepedunculatum
46 Urochloa mosambicensis
51 Non-edible weed
52 Edible non-weed

Code B
1 Whole plant
2 Fruits
3 Flowers
4 Leaves
5 Stems
6 Tubers
7 Corms
8 Rhizomes
9 Taproot
10 Seed
11 Roots
90 Other (specify)

Code C
1 Not enough time
2 Not needed
3 Dislike it
4 Not effective
5 Lack of knowledge
6 Not available (drought)
7 No groundnuts to accompany
8 Not available (unspecified)
90 Other (specify)
95 I don't know
999 NA
111 Not answered

Code D
1 Head
2 Wife/ husband
3 Daughter/ son
4 Mother/ father
5 Sister/ brother
6 Grandchild
7 Grandparent
8 Step child
9 Step parents
10 Mother/ father- in-law
11 Sister/brother-in-law
12 Daughter/ son- in-law
13 House girl
14 Farm labourer
15 Friend
16 Other family
90 Other (specify)

Code E
1 January
2 February
3 March
4 April
5 May
6 June
7 July
8 August
9 September
10 October
11 November
12 December
95 Unknown *(rainy season)*
999 NA

12

Questionnaire 13/17

Table 13: Edible weeds in the fields (2/2)

TYPE I.D.	(190) Do you preserve [TYPE]?	(191) In which months did you eat [TYPE] preserved?	(192) How many days per month did you eat [TYPE] preserved?	(193) How did you store [TYPE]?	(194) Why did you store [TYPE]?	(195) What's the percentage of loss during storage?	(196) Availability of [TYPE] compared to the last 5 years	(197) Consumption of [TYPE] compared to the last 5 years	(198) If consumption of [TYPE] has changed in any way, why?	(199) Do you give [TYPE] away for free?	(200) How much of the available [TYPE] did you collect?	(201) If more is available than was collected, why didn't you collect more?	(202) Cultivated last season	(203) Cultivated this season
	1 Yes 2 No If no cont. (196)	List all: A	Number 1-31	List all: B	List all: C	Percentage	D	D If no change, cont. (199)	List all: E	1 Yes 2 No	Percentage	List all: F	1 Yes 2 No	
01														
02														
03														
04														
05														
06														
07														
08														
09														
10														
11														
12														
13														

Codes 190-203: Weeds (2/2)

Code A
1 January
2 February
3 March
4 April
5 May
6 June
7 July
8 August
9 September
10 October
11 November
12 December
95 I don't know

Code B
1 Dried
2 Pulverized
3 Cured
4 Blanched
5 Raw/ fresh
90 Other (specify)
99 Not applicable

Code C
1To get higher prices in the future
2 Ensure food security in the future
3 Later exchange with other commodities
4 Own surplus
5 Seed saving
6 Tradition/how it is normally eaten
7 Taste is better preserved
90 Other (specify)
111 Unknown/Unlisted

Code D
1 Much more
2 Little more
3 Little less
4 Much less
5 No changes
99 N/A

Code E
1 Did not know about it
2 Less accessible
3 More accessible
4 Preferred other food
5 Not needed anymore
6 Lack of other foods
7 More food needed
8 Less food needed
9 Like the taste
10 Does not like it
11 Less available (drought)
12 Needed to supplement diet
13 Lack of knowledge
14 Less available (herbicides)
15 Lack of nshima
16 Changed diet
17 More healthy/ nutritious
18 To diversify diet
90 Other (specify)
99 Not applicable

Code F
1 Not enough time
2 Not needed
3 Dislike it
90 Other (specify)
95 I don't know
99 Not applicable

(204) ***Only if no edible weeds are used for food:*** **Why don't you use edible weeds*?*** *List all:_______ [Code G]* *[cont. (207)]*

(205) **Why do you use edible weeds in general*?*** *List all:____ [Code H]*

(206) **How important are the edible weeds/non-cultivated plants on the field/ on the field edges/ off-farm (e.g. forest, communal land) for your household in the last 12 months?** *[Beans method, 20 beans]*

	Field	Field edge	Off-farm *(e.g. forest, communal land)*
Amount of beans			

Codes 204-206: Edible weeds

Code G
1 Not available
2 Not accessible
3 Not traditional
4 Not preferred
5 PRF was sick
90 Other (specify)

Code H
1 Out of preference/ good taste
2 Source of income
3 Out of tradition
4 Exchange of other commodities
5 Supplement diet
6 Freely accessible
90 Other (specify)

Table 14: *Name the three most important weeds in general for… [use the Type IDs from table 13]*

	**Place (-) if not applicable*	*Type ID* 1.	2.	3.
(207)	**Name the three most important weeds for consumption:**			
(208)	**Name the three most important weeds for medicinal purposes:**			
(209)	**Name the three most important weeds for fodder:**			
(210)	**Name the three most delicious weeds:**			

(211) **Have you ever purchased edible weeds?** _____ *[1 Yes/ 2 No] (if No, cont. (215))*

(212) **Have you purchased edible weeds in the last 12 months?** _____ *[1 Yes/ 2 No] (if No, cont. (215))*

(213) **Which types have you purchased?** *List all: ______________________ [Code F]*

(214) **Where did you buy them?** _____ *[Code A]*

(215) **Have you ever sold edible weeds?** _____ *[1 Yes/ 2 No] (if No, cont. (223))*

(216) **Have you sold edible weeds in the last 12 months?** _____ *[1 Yes/ 2 No] (if No, cont. (223))*

Table 15: *List all edible, which were sold in the last 12 months*

TYPE I.D.	(217) Name of weed sold	(218) How much of [TYPE] do you sell?	(219) Who buys [TYPE] from you?	(220) Where do you sell [TYPE]?	(221) Total income from sale
	F	Percentage of total collected	List all: B	List all: C	ZK
01					
02					
03					
04					
05					
06					

(222) **Why do you sell edible weeds?** _____ *[Code D] (cont. 224)*

(223) **Why didn't you sell edible weeds?** _____ *[Code E]*

(224) **Do other farmers in the village sell edible weeds?** _____ *[1 Yes/ 2 No]*

Codes 213-223: Weeds sold

Code A
1 Market
2 Supermarket
3 Street vendors
4 Neighbors
5 Community members
90 Other (specify)

Code B
1 Small-scale trader
2 Large-scale trader/ wholesaler
3 Retailer/ marketer
4 Consumer
5 Cooperative
6 Processor
7 Through agent
90 Other (specify)
999 NA

Code C
1 Market
2 Supermarket
3 On the street
4 Neighbors
5 Community members
6 Hawking (door-to-door)
7 Homestead
90 Other (specify)
999 NA

Code D
1 High price
2 High demand (food scarcity)
3 High demand (popularity)
4 Have surplus
5 Necessity (financial)
6 Tradition
7 No self-use
90 Other (specify)
999 NA

Code E
1 Low price
2 No necessity
3 Self-use
4 Low demand (no food scarcity)
5 Low demand (everyone has it)
6 Access to market
7 Not a sellable
8 Less available
9 Too few to sell
10 Expensive to transport to market
11 No time to sell
90 Other (specify)
999 NA

Code F
1 Adenia gummifera
2 Adenia lobata
3 Adenia sp.
4 Aerva leucura
5 Alternanthera nodiflora
6 Alternanthera sessilis
7 Amaranthus graecizans
8 Amaranthus hybridus
9 Amaranthus sp.
10 Amaranthus spinosus
11 Amaranthus viridis
12 Aristolochia heppii
13 Bidens pilosa
14 Bidens schimperi
15 Bidens sp.
16 Boerhavia diffusa
17 Ceratotheca triloba
18 Cleome gynandra
19 Cleome hirta
20 Cleome monophylla
21 Commelina benghalensis
22 Commelina buchananii
23 Corchorus olitorius
24 Crotalaria cleomifolia
25 Cucumis anguria
26 Cucumis metuliferus
27 Cyperus auricomus
28 Euphorbia oatesii
29 Galinsoga parviflora
30 Hibiscus cannibinus
31 Hibiscus meeusei
32 Hibiscus platycalyx
33 Hygrophila sp.
34 Ipomoea obscura
35 Jacquemontia tammifolia
36 Ludwigia erecta
37 Ormocarpum kirkii
38 Portulaca oleracea
39 Senna obtusifolia
40 Sesamum angolense
41 Sesamum calycinum
42 Solanum nigrum
43 Tithonia diversifolia
44 Tribulus sp.
45 Tricliceras longepedunculatum
46 Urochloa mosambicensis
50 Unknown edible weed
51 Non-edible weed
52 Edible non-weed

16. <u>Edible Weed Perception</u> (PERSON RESPONSIBLE FOR FOOD)

Table 16: Please rank each statement or question accordingly from 1 to 5
** Using a hand to visualize the 5 categories (**EMPHASIZE POSSIBILITY OF NUMBERS IN BETWEEN)***

******* If the head of the household and the person responsible for food are the same: Ask only the questions that are bold and *******

	Statements and Questions	*1*	*2*	*3*	*4*	*5*	*95 I don't know*	*99 Not Applicable*
SOCIO-ECONOMIC								
(225)	How do edible weeds contribute to your household income? (1 no contribution at all - 5 high contribution)							
(226)	******Compared to now, how did edible weeds contribute to your household income in the past? (1 much lower contribution - 5 much higher contribution) 3 being the same**							
FOOD SECURITY								
(227)	******Only households with low income eat edible weeds (1 strongly disagree - 5 strongly agree)**							
(228)	How do edible weeds affect food accessibility? (1 very harmful– 5 very beneficial) **3 no effect**							
(229)	Edible weeds are especially important in times of food scarcity (1 strongly disagree - 5 strongly agree)							
HEALTH								
(230)	Edible weeds can be consumed even though insecticides are sprayed on the fields (1 strongly disagree - 5 strongly agree)							
(231)	How do you assess the nutritional value of edible weeds? (1 no value - 5 high value)							
(232)	******How important do you perceive edible weeds for medicinal purposes? (1 not important at all - 5 very important)**							
KNOWLEDGE								
(233)	In general, the elderly have a greater knowledge about edible weeds than youth (1 strongly disagree - 5 strongly agree)							
FARM PRACTICES								
(234)	How does fertilizer affect weed abundance? (1 greatly decreases - 5 greatly increases) **3 no effect**							
(235)	Less edible weeds are available as a result of herbicide usage (1 strongly disagree - 5 strongly agree)							
PESTICIDES								
(236)	To achieve a high yield, how important are herbicides compared to other inputs? (1 not important at all - 5 very important) **3 no effect**							
(237)	How do you perceive weed control compared to other challenges on the farm? (1 not problematic at all - 5 very problematic) **3 no effect**							
(238)	How do herbicides affect soil fertility? (1 very harmful - 5 very beneficial) **3 no effect**							
(239)	How do herbicides affect one's health? (1 very harmful - 5 very beneficial) **3 no effect**							
(240)	How do herbicides affect the surrounding environment of the farm? (1 very harmful - 5 very beneficial) **3 no effect**							

15

17. Knowledge, Networks (PERSON RESPONSIBLE FOR FOOD)

Table 17: Knowledge networks

Info TYPE I.D.	Type of information	(241) Do you have adequate information regarding [TYPE]?	(242) Where do you get information on [TYPE] from?	(243) Which of these sources is the most important?	(244) With how many people among your friends/relatives/neighbours did you talk about [TYPE] in the last 12 month?	(245) How many of these people are… Male	(246) Female	(247) Which gender do you perceive as more knowledgeable on [TYPE]?
		1 Yes 2 No	List all: A Try to capture all	A List only one	Number of people (if 0 cont. (247))	Number of people	Number of people	1 Men 2 Women 3 Both
01	Herbicides							
02	Nutrition (e.g. cooking, healthy eating)							
03	Edible weeds							

TYPE I.D	(248) Did you receive training on [TYPE]?	(249) From whom did you receive training?	(250) Please, rank the usefulness of the training.	(251) How many people did ask you for information on [TYPE] in the last 12 months?	(252) How many of these people are… Male	(253) Female	(254) Who asks you for information on [TYPE]?
	1 Yes 2 No (cont. (251))	List all: A Try to capture all	(1 not useful at all, 5 very useful) Emphasize possibility of numbers in between	Number of people (if 0, cont. with next TYPE)	Number of people	Number of people	List all: A Try to capture all
01							
02							
03							

Codes 242-254: Knowledge networks (2/2)

Code A

1 Government extension (Agriculture)
2 Government extension (Health)
3 NGO/ NGO extension
4 Private extension
5 Camp Officer
6 Neighbour
7 Friend
8 Parents/ Grandparents
9 Other relative (specify)
10 Other farmer
11 Women Group
12 Farmer group
13 Civil society organization
14 Farmer field school
15 Cooperative
16 Company (e.g. Bayer, NWK)
17 Out grower scheme
18 Market place
19 Traders / middleman
20 Agrochemical Dealer
21 Radio
22 Newspaper
23 Text messages (mobile phone)
24 Telephone call
25 TV
26 Internet
27 Information sheet
28 Books
29 Hospital/ Health Centre
30 Church
31 CFU
32 No source of information
90 Other (specify)

18. Household Food Security (PERSON RESPONSIBLE FOR FOOD)

(255) What is the main staple crop? _____ *[Code A]*

Table 18: Using the last 12 months for reference, please answer the following questions related to household food security

Months	(256) Please rank each month in terms of food availability for your household	(257) Indicate in which months you had [MAIN STAPLE CROP] available from your own production?	(258) Indicate in which months you bought [main staple crop]	(259) Indicate in which months you consumed vegetables from your own production?	(260) Indicate in which months you consumed vegetables that you gathered off the farm?	(261) Indicate in which months you bought vegetables for your own consumption	(262) Indicate in which months you consumed fish and/or meat from your own production, hunting and fishing?	(263) Indicate in which months you bought fish and/or meat for your own consumption?	(264) Indicate in in which months you did not have access to your preferred foods?
	B	1 Yes / 2 No	1 Yes / 2 No	1 Yes / 2 No	1 Yes / 2 No	1 Yes / 2 No	1 Yes / 2 No	1 Yes / 2 No	1 Yes / 2 No
Dec-17									
Jan-18									
Feb-18									
Mar-18									
Apr-18									
May 18									
Jun-18									
Jul-18									
Aug-18									
Sep-18									
Oct-18									
Nov-18									
Dec-18									
Jan-19									
Feb-19									

Codes 256-264: Household Food Security

Code A
1 Maize *4 Wheat*
2 Sorghum *5 Rice*
3 Cassava *90 Other (specify)*

Code B
1 Very Good *4 Bad*
2 Good *5 Very bad*
3 Normal *99 Not applicable*

END OF THE QUESTIONNAIRE

Is there anything you want to add?