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ROLE OF EDIBLE INSECTS IN FOOD SECURITY AND LIVELIHOODS IN MUMBWA DISTRICT, CENTRAL PROVINCE, ZAMBIA

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A research thesis submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfillment of the requirements for the award of the degree of Doctor of Philosophy

Supervisor: **Prof. Jasper Knight**

Date: **6th January 2025**

DECLARATION

I, John Nyawali declare that this thesis (data, figures, photos and tables) is my own original work. Where other people's ideas and figures were borrowed, such was acknowledged by use of quotation marks and referenced.

This thesis is submitted to the Faculty of Science at the University of the Witwatersrand, Johannesburg, South Africa, for the award of the degree of Doctor of Philosophy.

It has not previously been submitted for the award of a degree or examination at any University.



John Nyawali

Date: January 2025

DEDICATION

I dedicate this work to my family for giving me the inspiration to pursue postgraduate studies.

ACKNOWLEDGEMENTS

I wish to convey my heartfelt gratitude to Prof. Jasper Knight for his invaluable supervision encouragement and insight which provided guidance and mentorship in the production of this thesis.

I further wish to thank the Area Councilor for Kalwanyembe ward, Mr. Landson Sangwapo, and the traditional leadership in the Kaindu Chiefdom for granting me permission to conduct this study. I am equally indebted to the entire community of the Kaindu Chiefdom for their support and allowing me access to some sites and families and ensuring my safety while conducting ethnographic observations.

Special thanks to my family, Naomi, Takondwa and Thokozile for their corporation and financial support, without which, this undertaking could have not been possible.

Lastly, but not least, I would like to thank all individuals that gave me encouragement, guidance and motivation for me to soldier on with this work until its completion. I am forever indebted.

ABSTRACT

The need to find sustainable sources of food and livelihoods is one of the agendas of many societies. This is in response to an increase in global population and increasing number of hungry people globally. The threat of increasing food insecurity, especially in poor communities of sub-Saharan Africa, entails the need to find sustainable alternative sources of nutrition alongside conventional agriculture and food systems. The use of edible insects is seen as having potential to help bridge nutritional and food insecurity gaps as they are a good source of protein and could be part of resilient and sustainable food systems. Edible insects have also been part of cultural dietary practices in Africa for thousands of years. However, despite these advantages, the use of edible insects as food has declined in recent decades in many African communities that were previously known to have high consumption. This study examined the degree of acceptability of edible insects and their contribution to household food security and livelihoods in rural communities in Mumbwa district of Central Province, Zambia. A mixed method research strategy was used across four administrative zones of the study area to collect data through questionnaires, observation and focus group discussions with adult participants (18 years and above). Ethnographic observations were also made on how rural residents engage and utilize edible insects as a resource, including how they find, harvest and prepare insects from natural settings. Results show that the majority (68%) of surveyed households consumed edible insects. This is attributed to the fact that entomophagy forms part of the food culture of the dominant local Kaonde ethnic group. Edible insects were also used as a means to promote social cohesion and cultural values. Edible insects were also a source of livelihood for 26% of respondents, with income from the sale of edible insects being similar to the total income generated from agricultural activities for the majority of households in the community. It was reported that the income generated from the sale of insects, especially caterpillars, was much higher than maize, as a 5-litre bucket of caterpillars sells for around K300 (about US$11) during the harvest season and K500 (about $19) in the off season. In some cases, the income was higher depending on the type and quantity of the caterpillar species being sold while the same quantity of maize grain sold for K20 ($0.75) during harvest season (June–August) and K50 ($2) off season (October until the next harvest season). This means that trade in edible insects could help mitigate poverty among rural households. Impediments to the utilization of edible insects as a source of livelihood include the reduction in insect population and availability, lack of infrastructure to promote trade, and lack of environmental stewardship to enhance ecosystems protection. Reduced availability of insects in this community was attributed to

climate change, habitat destruction and lack of effective management. To ensure sustainable livelihoods and food security in rural communities, there is need to maintain ecosystems in good condition as well as recognizing edible insects as finite valuable resources that should be managed. This requires adequate infrastructure and public policy cutting across socioeconomic, health, education and trade/business systems. Better governance and coordination across different actors involving edible insects as a form of natural capital can help achieve various Sustainable Development Goals of relevance to rural African communities.

Keywords: Food security, livelihoods, sustainability, edible insects, ecosystem services, acculturation, entomophagy

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LIST OF ABBREVIATIONS

Acronym	*Description*
CBD	Convention on Biological Diversity
CSO	Central Statistical Office
DNPW	Department of National Parks and Wildlife
DRC	Democratic Republic of Congo
FAO	Food and Agriculture Organization
FBA	Food Business Africa
FGD	Focus Group Discussion
GFW	Global Forest Watch
GMA	Game Management Area
HLPE	High Level Panel of Experts on Food Security and Nutrition
ILUA	Integrated Land Use Management
IPC	Integrated Food Security Phase Classification
ITCZ	Inter-Tropical Convergence Zone
JICA	Japan International Cooperation Agency
LCMS	Living Conditions and Monitoring Survey
MEA	Millennium Ecosystem Services
MLNREP	Ministry of Lands Natural Resources and Environmental Protection
NBSAP	National Biodiversity Strategy Plan
SDGs	Sustainable Development Goals
SES	Social-Ecological Systems
UN	United Nations
UNICEF	United Nations Children Emergency Fund
WFP	World Food Program
ZAMSTATS	Zambia Statistical Agency
ZAWA	Zambia Wildlife Authority

Chapter 1: INTRODUCTION

1.1 Background

Entomophagy, which is the consumption of insects by humans and animals, is practiced in many parts of the world, mostly in Africa, Asia and Latin America where edible insects are part of people's history, customs and culture (Meyer-Rochow, 1975; Ramos-Elorduy; 2005; Van Huis *et al.,* 2013). The number of people that are said to consume edible insects globally is not known especially that the Food and Agricultural Organization (FAO) does not itself collect data statistics at national, regional and global levels (Van Huis *et al.,* 2022). However, considering that entomophagy is practiced in 48 countries in Africa, 52 countries in Asia and 15 countries in South America (Omuse *et al.*, 2024), it is likely that several hundreds of millions of people globally consume insects at some point as part of their dietary preferences or as means of survival due to food insecurity.

Historically, entomophagy has been part of human diets for thousands of years (Holt, 1885; Bequaert, 1921; Bodenheimer, 1951; Van Huis, 2003; O'Malley and McGrew, 2014; Olivadese and Dindo 2023). The discovery of insect chitin in human coproliths dating back to almost 10,000 years shows evidence of entomophagy among humans in prehistoric times (Elias, 2009). Van Huis (2003) states that entomophagy was commonly practiced by the early human ancestors and also in ancient China, Rome and Greece. Thompson (1910) in his publication *Historia Animalium* as cited by Olivadese and Dindo (2023), and historical sources such as philosopher and naturalist Aristotle, mentioned that caterpillars were used as food and also considered as a delicacy by the ancient Greeks. Additionally, Wallace-Hadril (1990) indicates that Pliny the Elder, a Roman author and naturalist who lived in the first century AD, in his book *Naturalis Historia* mentioned the consumption of caterpillars, the larvae stage of moth or butterflies belonging to the order *Lepidopera: Papilionoidea*, *Macrotermes* Smeathman 1781, *Locusta migratoria* Linnaeus 1758 (locusts) and *Acridoidea* Macleay 1821 (grasshoppers) by the ancient Romans.

Chinese classical writings dating back more than 3000 years advocated for the use of edible insects in human diets (Holt, 1885; Bodenheimer, 1951). In Africa, entomophagy has been part of the food culture of different communities since prehistoric times (Malaisse, 2005; Ramos-Elorduy, 2005). This shows that entomophagy has been practiced globally with taste preference, social significance and geographical location playing important roles (O'Malley

and McGrew, 2014). Consumption of edible insects has also been used as a strategy to address problems of food insecurities in some communities following challenges that the agriculture sector experiences partly due to climate change (Knox *et al*., 2012; Nyangena *et al.*, 2020), soil quality and land degradation, poor agronomic practices in food production systems Birch *et al.,* 2019) and limited access to improved agricultural inputs (IFAD, 2019).

The threat of increasing food insecurity, especially in poor communities of sub-Saharan Africa, entails the need to find sustainable alternative sources of nutrition alongside that provided by conventional agriculture. Some researchers (e.g. Meyer-Rochow, 1975; Van Huis *et al.,* 2013) and international organizations have argued that edible insects could help bridge nutritional and food insecurity gaps because edible insects are known to be a good source of dietary proteins, vitamins, and macro and micro nutrients (Rumpold and Schluter, 2013; Gahukar, 2018; Van Huis *et al.,* 2021). For example, a study of nutrition composition of 54 different edible insects consumed in southern Africa found that some were a good source of minerals such as zinc and iron, with fat content up to 51% and protein content from 12 to 79% (Hlongwane *et al.,* 2020), which was higher than protein found in chickens (43%) or beef (54%) (Teffo *et al.,* 2007; Blásquez *et al.,* 2012).

In India, five insect species were compared for nutritional values. A high protein content was found in dragonflies (*Odonata: Anisoptera*), drury (*Cyclosia papilopnaris*) larvae, grasshoppers (*Orthoptera: Acrididae*) and silkworms (*Bombyx mori* L.); while considerably high content of fat, fiber, essential amino acids and minerals (sodium, potassium, calcium, magnesium, iron, and zinc) were found in stink bugs (***Encosternum delegorguei)*** and termites *Macrotermes falciger* (Gahukar, 2018). The nutritional content of some edible insects was equal or significantly higher to those found in beef, pork, chicken, eggs, or lamb (Orkusz, 2021) and satisfied the recommended daily allowance recommended by FAO/WHO, therefore representing a viable food source. However, edible insects are comparatively low on carbohydrates, and as such one would require huge quantities to acquire the total daily energy requirement (Williams and Williams, 2017).

In addition to the nutritional value, edible insects can be part of sustainable food systems, especially those that are collected from the natural environment by local communities. The High Level Panel of Experts on Food Security and Nutrition (HLPE) states that sustainable food systems are those that consider social, economic and environmental aspects in the

production of food and nutrition for all, without compromising the future generation's food and nutrition security (HLPE, 2014). This means that for food systems to be beneficial to communities, food must be easily accessed and available to people with minimal damage to the environment from production, input processes, preparation and transportation to the end user. Sustainable food systems are therefore a product of several other systems (ecological, health, economic and socio-cultural elements) and how they interact with each other, and thus these interconnections need to be considered in all types of food systems (Clapp *et al.,* 2022).

However, despite edible insects being nutritionally rich in proteins, fats, minerals and vitamins and being a possible source of sustainable diet (Van Huis *et al*., 2013, Tao and Li, 2018; Tang *et al.,* 2019, Papastavropoulou *et al.,* 2021; Clapp *et al.,* 2022), their usage or acceptability as food has declined in the 21st Century globally, particularly in some African communities that were known to have had previously high consumption (Anankware *et al*., 2017; Manditsera *et al.,* 2018; Hlongwane *et al.,* 2021). For example, studies in South Africa (Hlongwane *et al.,* 2021), Ghana (Anankware *et al*., 2017) and Zimbabwe (Manditsera *et al.,* 2018) found that there was a declining trend in consumption of edible insects especially in urban areas due to acculturation, discomfort associated with insect consumption, increased diversity of other food choices, and declining availability of edible insects. Socio-demographic factors such as gender, age, and education background also play a significant role in influencing the acceptability and choice of edible insects in African communities (Anankware *et al*., 2017; Hlongwane *et al.,* 2021).

Individual communities may have unique and different experiences of utilizing edible insects depending on climatic and ecological characteristics, culture, geographical location, season and religious beliefs. For example, in Burkina Faso, edible insects are a dietary supplement for many people, however in Liberia the consumption of edible insects is widely accepted by people of all ages and genders, including pregnant women, to promote the health of both the mother and unborn child (Séré *et al.*, 2018). In Congo, consumption of edible insects was estimated at 30 g per person per day (Bomolo *et al*., 2017), while in Zambia, caterpillars such as *Gonimbrasia belina*, *Gynanisa maja* and entomophagy in general form a large part of the diet for most people in rural areas when edible insects are in season (Siulapwa *et al.,* 2014; Stull *et al*., 2018). In Zimbabwe, insects form an important part of rural diets and are used as relish in addition to staple foods (Manditsera *et al.,* 2018). In Benin, communities have relied on edible insects as important sources of food and nutrition (Séré *et al.,* 2018; Tchibozo, 2023).

The Pedi tribe of South Africa preferred eating edible insects over meat (Hlongwane *et al.,* 2021). In Uganda and Kenya, grasshoppers (*Ruspolia differens* and *Ruspolia*) are served as a delicacy during family functions and black ants (*Carebara vidua*) are a favorite dish among the Luo tribe of Kenya (Ayieko *et al.,* 2012; Mmari *et al*., 2017).

Studies further show that edible insects such as grasshoppers, locusts and caterpillars have been used as food in many communities in Ghana (Anakware *et al.,* 2017), Kenya (Mmari *et al.,* 2017), South Africa (Hlongwane *et al.,* 2021), Zambia (Stull *et al.,* 2018) and Zimbabwe (Manditsera *et al.,* 2018). Additionally, Coleopteran insects were preferred by indigenous communities in northeast India while Odonata and blattoptera were the least favoured (Ronghang and Ahmed, 2010; Chakravorty *et al.,* 2013). Different trends shown above indicate that consumption of edible insects may be practiced not only in times of food shortages but may also be an expression of social, cultural significance, identity (Ramos-Elorduy, 2009), preferences, and diversity (Ghosh *et al.,* 2018).

Entomophagy in some communities may also be practiced due to awareness of the nutritional value of some edible insects and not necessarily as a survival strategy due to lack of food (Yen, 2010, Costa-Neto, 2016). In India, specific insects such as termites, honey bees, grasshoppers, stink bugs, aquatic insects and silk worms are purposely selected for consumption because they are known to contain high amounts of protein, fat, minerals and vitamins (Gahukar, 2018). In that regard, history, traditions, familiarity, religious and traditional beliefs and how information on insects as human food is conveyed to people also matters (Ghosh *et al.,* 2018).

Other considerations that may influence insect utilization may include stage of development of particular insect species, nutritional quality and preparation methods (Meyer-Rochow, 2021), economic considerations such as time and cost involved in harvesting, purchasing and energy used to collect the insect, (Ghosh *et al.,* 2018). Seasonal variations may further influence insect availability and their consumption since insect availability depends on the season of the year. During peak seasons when insects are available, communities tend to consume more edible insects than off seasons (Van Huis *et al*., 2013; Stull *et al*., 2018; Abdullahi *et al.*, 2021; Tagawa *et al.,* 2022). Additionally, the diversity and abundance of edible insects is dependent on conditions of the natural environment. The reduction of wild insect availability worldwide is attributed to habitat loss and degradation due to urbanization (Kehoe *et al.,* 2021). Increased human activities such as settlements and expanding agricultural areas cause removal and

decline of host plants for edible insects, leading to fragmented and smaller insect populations (Ghosh *et al.,* 2018; Goulson, 2019). For example, in Germany, 76% reduction of biomass leading to reduction in insect population was recorded, while between 75–98% of biomass loss leading to loss of insect population such as butterflies was recorded in Puerto Rico (Goulson, 2019). In Cameroon, urbanization resulted in habitat change across regions, causing reductions in insect population and diversity **(**Félix, 2019). In Zambia, populations of butterflies *(Lepidopera: Papilionoidea)*, dragonflies (*Odonata: Anisoptera*) and other macroinvertebrates have significantly declined in the Kafue terrestrial and aquatic ecosystems due to anthropogenic activities (MLNREP, 2015). Similarly, the number of caterpillars in districts such as Mpika and Chinsali in the Central Province of Zambia has also decreased (Mbata *et al.,* 2002). This means that environmental degradation such as habitat loss and climate change may influence insect availability and the likelihood of entomophagy to take place.

Insects in general play an important role in ecosystem services since they form part of terrestrial and aquatic food webs (MEA, 2005; Williams and Williams, 2017; Goulson, 2019). Insects help promote health and resilient agriculture systems through regulating and supporting services (Adolf *et al.,* 2023). For example, honey bees (*Apis mellifera*) provide pollination ecosystems to agriculture production (Ortiz *et al.,* 2021). This helps to improve crop yields, thereby, contributing to food security. Some insect species help to reduce pests and pathogens in crop fields as natural pest controllers. However, with expanding agriculture, there is increased use of agrochemicals such as pesticides, herbicides and fungicides threatens ecosystems that are important to insect biodiversity as cultivation of crops is often done in areas of high biodiversity value (Wagner *et al*., 2021; Adolf *et al.,* 2023). With global populations increasing, ecosystem services are being degraded in many regions.

The pressure on ecosystem services now risks ecological collapse despite the economic and social value that insects give to society (Campos *et al.,* 2021). This means that there is a need to understand the impacts of agriculture on insect populations and the effects that insect scarcity may have on food security and rural livelihoods. Insect distributions, population and availability also respond to climate change (Nyangena *et al.,* 2020), ecosystem dynamics and how communities could utilize them (Payne and Itterbeeck, 2017). For example, rainfall variability and higher temperatures in Zambia are expected to negatively affect insect species and ecosystems (MLNREP, 2015). However, there is very little research on how climate

change affects edible insects, therefore there is a need to understand future changes in insect availability and their impacts on rural communities.

In times of food scarcity, edible insects are used by some communities as an emergence source of food (Van Huis *et al.,* 2013). However, in other situations, some species of insects are not used for food but have other uses such as for medicines and ornaments (Meyer-Rochow, 2017; Matandirotya *et al.,* 2022). Since rural people are dominantly the collectors and majority users of edible insects, they are most likely to have acquired traditional knowledge and skills about insects and their uses (Hlongwane *et al.,* 2021). Traditional knowledge has played a vital role in utilization of edible insects in many communities in countries such as India (Mozhui *et al*., 2017; Ghosh *et al.,* 2018), South Africa (Hlongwane *et al.,* 2021) and Zimbabwe (Manditsera *et al.,* 2018) and traditional knowledge holders are likely to know about the life history, locations, harvesting methods and uses of various insect species. However, traditional knowledge on edible insects has been decreasing in many communities (Manditsera *et al.,* 2018; Ghosh *et al.,* 2018; Hlongwane *et al.,* 2021). This poses challenges such as insect over-exploitation or the use of unsustainable collection methods (Ramos-Elorduy, 2009; FAO, 2016).

In as much as traditional knowledge and culture is important in the utilization of edible insects, some local African traditions, beliefs and cultural practices prevent some groups such as women and children from benefiting from their consumption. For example, women of Baganda in Uganda are not allowed to eat edible grasshoppers any form of grasshoppers (*Orthoptera: Acrididae*) yet they are the ones that collect and cook them while pregnant women in many regions of Africa are prohibited from consuming any kind of grasshoppers due to some beliefs (Mmari *et al*., 2017). In Uganda, certain types of grasshoppers specifically *Ruspolia nitidula* are expensive and considered to be a delicacy (Agea *et al*., 2008). This means that although consuming certain types of edible insects is meant to protect people from health hazards and promote spiritual wellbeing (Meyer-Rochow, 2009), cultural contexts could be a barrier to effective utilization of edible insects in some communities.

In many developing countries, consumers have expanded their food choices over recent decades to align with modern Western lifestyles and, as such, consumers are often faced with many food choices. Stereotypes and prejudices associated with consumption of edible insects make it difficult for some people to share their knowledge and experiences for fear of being

judged (Ramos-Elorduy, 2009). For example, although consumption of edible insects was common in Zambia, utilization was underexplored as insects were not equally valued and their use as food was influenced by social values (Stull *et al*., 2018). In Mali, local people found it uncomfortable to share their knowledge and experiences of edible insects with strangers because of their fear that they would be considered as uncivilized (Looy *et al*., 2013).

Considering that diets have changed over time and consumers' food habits are susceptible to change, it is important to understand the factors that affect insect consumption in indigenous communities. Utilization of edible insects could be embedded in the community's knowledge of insect types, values, perceptions and methods of preparation and cultures of consumption. Like any other food, the significance of edible insects to food security could be boosted by their availability, accessibility and utilization. Communities with high knowledge of edible insects may utilize these resources more efficiently. For example, about 28% of people in the province of Katanga in the Democratic Republic of Congo (DRC) consume insects, especially caterpillars, and about 65 species of insects are considered as food (Bomolo *et al*., 2017). Insect consumption patterns show marked differences in different locations, hence the need to understand the values that communities place on edible insects, why they perceive edible insects in the way they do, and identification of any other factors that may influence their consumption.

To overcome challenges of declining practice of entomophagy among different demographic, gender and cultural groups, strategies have been developed to use the derived products of edible insects to processed food, such as meal flour, biscuits and snacks (Elhassan *et al.,* 2018). For example, enriching boiled bananas and cereal porridge with extracts of grasshoppers has been used in Tanzania to address child malnutrition (Mmari *et al.,* 2017). In the DRC, cereal made from dried caterpillar mixed with other ingredients was given to malnourished children and the food mix was widely accepted by mothers and children (Bauserman *et al.,* 2015). The same was done in Kenya where winged termites (*Macrotermes falciger)* were utilized to enrich amaranth foods (Kinyuru *et al*., 2012). The strategies can help address nutritional and food insecurities in marginalized communities as there is higher acceptability of insect-enriched food than whole insect structure (Tang *et al.,* 2019). Different processing methods can increase insect palatability, safety and preservation (Meyer-Rochow *et al.,* 2021). Common methods include boiling, smoking, toasting, deep frying, sun drying and fermentation depending on the

type of insects considered (Mmari *et al*., 2017; Kewuyemi *et al.,* 2020; Meyer-Rochow *et al.,* 2021).

Collection and trade in edible insects have evolved over the years in many regions from domestic use to trade in local (Losey and Vaughan, 2006; Sekonya *et al*., 2020), regional (Makhado *et al*., 2014) and international markets (Van Huis *et al.,* 2013; Chia *et al*., 2019). Increase in demand for edible insects has caused wild harvested insects to become a source of income for many rural households in the developing world. For example, in the Central African Republic, 95% of the population consume insects on a daily basis (FAO, 2004). In Laos, 21 species of edible insects are sold at fresh food markets (Boulidam, 2010). It is projected that with an increase in rural poverty, more people will turn to edible insects as a source of domestic food and external income (Van Huis *et al.,* 2013). This means that demand for edible insects may put these resources under pressure and lead to decline in insect availability and biodiversity. For example, a decline in population of mopane worms has been reported in some countries in southern Africa (Toms and Thagwana, 2005). In East and Central Africa, about 34 species of edible insects have been listed as endangered as a result of a range of anthropogenic activities (FAO, 2016).

Owing to the popularity and significance that some societies attach to some species of edible insects, technologies are being developed to start commercial farming of caterpillars (Ghaly, 2009), grasshoppers and mealworms in controlled environments to ensure their availability and to maximize production (Van Huis *et al.,* 2013; Selaledi *et al.,* 2021). For example, in Zambia it was shown to be possible to farm mopane worms commercially as a protein source (Ghaly, 2009). However, insect farming requires capital investment and secured land, and as such rural people who depend on edible insects for food and livelihoods may be excluded. This means that their sustainable management in the wild could be more beneficial to indigenous communities.

In Zambia, primary drivers of biodiversity loss, particularly of insects, include agriculture, charcoal burning and wild fires (Chidumayo, 2002; Mulenga *et al.,* 2017). It is estimated that the country loses between 144 000 to 445 000 hectares of forest per annum, which translates to 0.37% loss of forest per annum (GFW, 2018). This places Zambia among the largest deforested countries in the world. In addition to charcoal burning as a byproduct of forest clearance, settlement expansion is also a major factor for degradation of habitats and

deforestation in rural areas (FAO/UNEP, 2020). For example, crop failure and food insecurity in some parts of Zambia have forced some people to migrate to more agro-ecologically suitable land such as Game Management Areas and forests (DNPW, 2013). Establishment of village settlements in ecologically sensitive areas may reduce insect populations as a result of changes in natural ecosystems by agriculture and land degradation.

Forest ecosystems are an important repository for biodiversity that include edible insects as part of their ecosystems services. However, there has been little attention paid to the role of edible insects such as mopane worms, flying termites, locusts and grasshoppers in the food mix and livelihoods of communities around forested and conservancy areas such as in Zambia. Exclusion of edible insects as economic and food resources may lead to their mismanagement, underutilization or undervaluing as part of different ecosystem services. Additionally, it is also not clear how socioeconomic and demographic factors influence the consumption of edible insects. Use of these resources may play a significant role in poverty alleviation and improved food security if challenges and opportunities in the edible insect sector were well identified and understood. Therefore, this research generates knowledge needed for sustainable management and utilization of edible insects and further helps identify the factors underlying their utilization in rural communities.

1.2 Problem statement

In 2023, Zambia's population was 20.57 million people with an annual growth rate of 2.7% and birth rate of 34.14 per one thousand inhabitants (Statista, 2023). Most (60%) of Zambia's population lives in rural areas with the majority depending on the exploitation of ecological and agricultural resources for their livelihoods (CSO, 2010; MLNREP, 2015). People in rural Zambia remain predominantly poor with poverty levels standing at 76.6% of which 53.4% live below the poverty datum line (LCMS, 2015). The national average monthly income for rural households is 810 Kwacha (US$38) of which K430 (US$20) (53%) accounts for monthly food expenditure (LCMS, 2015). An outcome is that 48% of people in rural areas are food-restricted while 14% of children under the age of five suffer from severe malnutrition and 35% have stunted growth (IPC, 2022).

In 2022, 40% of Zambia's population was facing acute food insecurity due to high food, fuel and farming input prices (WFP, 2022). In Central Province of Zambia where the study area of Mumbwa district is located, 30% of the population was facing food insecurity and 56% of

people were considered to be poor despite the fact that edible insects are abundant in many rural areas of the country (CSO, 2010; IPC, 2022). Zambia has a diverse range and number of edible and economically important insect species (MLNREP, 2015). In total, 84 species of edible insects are consumed countrywide and 27 species of grasshoppers are endemic to Zambia (MLNR, 1999; Jongema, 2014).

In recent years, Mumbwa as a whole has been undergoing rapid development of commercial farms and urban settlements (Chu and Phiri, 2015), which may lead to loss of habitat suitable for insects. Additionally, expanding agricultural land threatens ecosystem services and biodiversity that are crucial to the maintenance of sustainable food systems of which insects are part (Adolf *et al.*, 2023). For example, maize and legumes are the most important and widely cultivated crops in Zambia (FAO, 2022). The use of herbicides and pesticides as pest control methods in agricultural crop fields may pose a threat to insect populations and their contribution to food security and healthy ecosystems through pollination and soil enrichment services may be inhibited. This can lead to high negative ecological impacts within and around areas of high biodiversity value (Adolf *et al.,* 2023).

While the economic importance of some edible insects such as caterpillars and honey bees has been partially documented, little is known about how other species of edible insects contribute to rural livelihoods and food security. For example, studies indicate that 41–43% of people in rural communities of Mumbwa district depend on edible insect resources for food (Mulenga *et al*., 2014; Ngoma *et al*., 2019). Some studies have investigated the acceptability of entomophagy in general in Zambia (Mulenga *et al*., 2014; Stull *et al.,* 2018; Ngoma *et al*., 2019) while Mbata *et al.* (2002) looked at the use of traditional knowledge in conserving habitats for certain edible insects, particularly caterpillars. However, these studies did not analyze how people of different age groups, gender, cultural background and socioeconomic status utilize different types of edible insects.

Failure to understand factors causing underutilization of edible insects may lead to the neglect of insect resources and communities to miss out on potential socioeconomic benefits and loss of cultural knowledge. This may exacerbate rural food insecurity and poverty, habitat degradation and inhibit benefits of ecosystem services. In addition, rising costs of food, fuel, farming inputs and climatic shocks are expected to worsen the current food insecurity and nutrition problems (Cafiero *et al.,* 2023). This means that livelihood opportunities may reduce

and poverty levels increase, hence the need for strategies that will improve local food security and development of sustainable and climate-resilient livelihoods.

1.3 Study aims

The aim of this study is to analyze and understand the degree of acceptability of edible insects and the extent to which they contribute to household food security and livelihoods of people in rural areas of Mumbwa district of Central Province in Zambia. The research further endeavors to identify the demographic, cultural and societal factors that affect the sustainable utilization of edible insects.

1.4 Study objectives

To address this study aim, the following objectives are identified:

1. To evaluate the contribution of edible insects to food security and livelihoods of people in rural areas of Mumbwa district, Zambia.
2. To have insights of the local food system and food coping strategies of households under periods of socioeconomic and environmental stress.
3. To identify and synthesize information on how cultural perceptions, attitudes and knowledge of edible insects shaped the pattern of usage among different community members in the study area.
4. To assess whether and why trends of edible insect utilization have changed over time, in order to consider how the sustainable utilization of insect resources can be used to support food security and livelihood strategies in rural Zambia.

1.5 Justification and significance of the study

The significant shortages in essential food intake particularly of micronutrients and protein, hunger and food insecurity problems that many communities in the developing world, particularly in Africa, experience calls for a paradigm shift to effectively fight or manage these problems. The urgency to find alternative and sustainable food sources particularly protein has been backed by several international organizations dealing with the food sector such as CGIAR and the Food and Agricultural Organization (FAO) of the United Nations (OECD/FAO, 2020). This is because the current food systems and the sources of protein they provide are not adequate to meet the increasing world demand for food amid falling agriculture production and increasing environmental degradation (Van Huis *et al.,* 2013; OECD/FAO, 2020). For example, efforts to increase animal protein in Brazil resulted in 38% loss of forested areas

(Govorushko, 2019). This indicates the need for research into alternative sources of food that are sustainable, have high socioeconomic benefits and less environmental impact. In that perspective, edible insects present an alternative food source to address increasing rural hunger, malnutrition and poverty. This is because edible insects have the capacity to improve economic status, sustain ecosystem services, and contribute to human wellbeing (Papastavropoulou *et al.,* 2021). Additionally, edible insects are considered to be healthier because of their richness in proteins, fats, and minerals, and are considered cleaner because most of them feed on plant leaves, and are mainly collected from the wild (Chakravorty *et al.,* 2011; Ghosh *et al.,* 2019; Feng *et al.,* 2019; Govorushko, 2019; Meyer-Rochow *et al.,* 2021; Van Huis *et al.,* 2021).

There are varying numbers and species of insects that are consumed at country and continental levels despite their economic and environmental benefits (Van Huis *et al.,* 2013). This partly depends on environmental, climatic and ecological conditions (Ghosh *et al.,* 2018; Müller, 2019; Meyer-Rochow *et al.,* 2021). For example, insects are more consumed in the tropics probably because insects in these zones are larger in size and are easily found for the most parts of the year (Van Huis, 2018; Oonincx and Finke 2021). In Africa, at least 48 countries practice entomophagy and a total of 470 species of edible insects are recognized on the continent (Kelemu *et al.,* 2016; Omuse *et al.,* 2024). In South America, about 450 species of edible insects are available with Mexico and Brazil having considerably high numbers of edible insect species (Van Huis *et al.,* 2013; Omuse *et al.,* 2024) while in Asia, India has about 262 recognized species of edible insects, (Omuse *et al.,* 2024), 235 species in China, (Cheng *et al.,* 2009; Feng *et al.,* 2019; Omuse *et al.,* 2024) and 272 species in Thailand (Omuse *et al.,* 2024). However, the presence of different species of edible insects does not necessarily influence the practice of entomophagy in different continents and countries. For example, in Latin America, 39% of rural residents practice entomophagy whereas in Africa it is 30% (Papastavropoulou *et al.,* 2021). This suggests that entomophagy is still relatively underdeveloped in Africa despite having high insect biodiversity across the entire continent compared to a single country like Mexico which utilizes a wide range of recognized species of edible insects (Van Huis *et al.,* 2013). This may also reflect a lack of knowledge and research on insect species in different environments, and a lack of understanding on insect consumption in Africa.

Owing to an increasing demand for edible insects in recent years, some countries like China have seen an increased number of patent applications for the development of edible insect farming practices (Feng *et al.,* 2019). Technology and infrastructure have been developed to

support the storage of edible insects in different forms such as fresh, dried, frozen and canned, and for long term use in different markets. This indicates that in China, entomophagy is well established in bringing all production and marketing elements together to exploit these resources.

In Africa and Zambia in particular, research on the role of edible insects as an economic and food resource remain under researched and poorly understood. The existing literature is focused on a few specific insects, caterpillars (Mbata *et al*., 2002; Ghaly, 2009) and honey bees (Mickels-Kokwe, 2006) considered to be economically significant, to the neglect of other species. Studies by Mbata *et al*. (2002) and Stull *et al*. (2018) have shown different styles of edible insect utilization in different communities in Zambia but have not explored the factors that influence these variations. In Zambia, there are around 6135 species of invertebrates of which insects are the most diverse, with 172 species of grasshoppers, 27 of which are endemic (MLNREP, 2015). The number of edible insect species in Zambia ranges between 25 and 50, depending on their availability and cultural context (Jongema, 2017). Common among these are caterpillars, grasshoppers, flying termites and cicadas (Defoliart, 2002; Siulapwa *et al.*, 2014).

Zambia's forest ecosystems provide a variety of products and services that include edible insects that contribute to livelihoods and wellbeing for people in rural areas (Ngoma *et al.*, 2019). It is estimated that forest ecosystems in Zambia contribute 4.7% of gross domestic product and that rural households earn up to 30% of their income from non-timber forest products (World Bank, 2020; FAO, 2022). Recent increased demand for Zambian honey has been noted with honey producers exporting 2500 metric tons to international markets (FBA, 2018). A lack of awareness of edible insects and products has meant that their role in poverty alleviation, food security and socioecological interaction is less well understood when compared to agriculture. This may lead to environmental and habitat degradation, which may have negative effects on communities that rely on insect ecosystem services for food and livelihoods.

Currently, more than half of Zambia's total population (18.4 million people) live below the poverty line of which 77% live in rural areas. Nine in ten people consume less than the recommended amounts of vitamins and minerals per day while 48% of the population does not receive the minimum calorific requirement (WFP, 2022). This shows that undernutrition and

poverty still remain high in Zambia and that conventional agriculture on its own may not be adequate to combat hunger and poverty. However, in many communities the consumption of edible insects as mainstream food has negative perceptions and are only considered in times of famine and as a last resort (Papastavropoulou *et al.*, 2022). Lack of knowledge on good nutrition, and poor feeding habits and unhealthy diets especially in poor rural and urban communities, are identified as key issues in Zambia (WFP, 2022). Additionally, information on edible insect species diversity is poor, making it difficult to know the trends of insect utilization as well as understand the value of different types of insects to communities.

This study will add to the body of scientific knowledge on edible insect use as sources of food products and their contribution to livelihoods in rural communities of Zambia. The study will identify current and emerging trends in the insect sector and identify areas of further research in the field of food security, ecosystem services and sustainability to ensure efficient utilization of a variety of edible insects in the developing world.

Chapter 2: LITERATURE REVIEW

This literature review examines major debate around edible insects as economic and food resources at global, regional and national level. It also looks at specific trends in the utilization of edible insects, influence of culture, and socioecological and sustainability challenges faced by local communities in the use of these resources.

2.1 Global and regional perspectives

The increase in human population in developing countries is expected to lead to an increase in demand for food by 60% by 2050 and in some instances, cause food shortages exacerbated by climate shocks (OECD/FAO, 2020; FAO, 2022). In Africa, the population is expected to increase to about 2.53 billion people by 2050 (Statista, 2023). The problem of food insecurity and undernutrition in the developing countries especially Africa has continued, worsened by poverty, climate change, water scarcity and land degradation (OECD/FAO, 2020; Saddiqui *et al.,* 2023). The inadequate food supply and the available foods that are mostly of poor quality contribute to chronic hunger and malnutrition (Saddiqui *et al.*, 2023).

It has been observed that the world has not made progress in eradicating malnutrition and hunger for all people, in that the number of hungry people globally increased to 9.9% in 2020 from 8.4% in the previous year and about 30% of the global population suffer from severe malnutrition (FAO, 2021). Lack of global progress in eradicating hunger and malnutrition is an impediment to achieving the United Nations' Sustainable Development Goals (SDGs) of which SDG 2 aims at ending world hunger and malnutrition by 2030. Further, extreme hunger and malnutrition becomes a barrier to achieving other SDGs such as ending poverty (SDG 1), achieving good health and wellbeing (SDG 3), and reduced inequalities (SDG 10). This is because hunger is symptomatic of other societal and socioeconomic issues and may cause people to be less productive, more prone to ill health and less able to support their families and communities.

The current global arable land and water resources used for food production are not enough to meet the food requirements of a growing population especially in developing countries (UN, 2019). Existing food production systems are also likely to be challenged by effects of extreme weather events such as droughts and floods and land degradation (OECD/FAO, 2020; Ponce

Reyes and Lessard, 2021). This will mostly affect low-income countries leading to increased levels of poverty and malnutrition (Premalatha *et al.,* 2011; Lange and Nakamura, 2021).

In Africa, there are various diets that are consumed across different regions and communities owing to the diverse socio-cultural and physical and ecological environments (Oniang *et al.,* 2003; Oruikor *et al.,* 2023). However, there are similarities in the dietary practices of most African communities as people rely on the consumption of starchy staple foods mainly consisting of cereals (maize, sorghum, millet, teff) roots and tubers (cassava, cocoyam, yam) and green bananas or plantain which are complemented by accompaniments (known as relish) comprising of leafy green vegetables, dishes made from legumes, and sometimes meat or fish whenever available (Oniang *et al.,* 2003). This shows that diets for many people in Africa lack diversity and the consumption of food with high nutritional value is low (Oruikor *et al.,* 2023). For example, 50% of the Kenyan population suffer from different levels of iron deficiency anemia (Oniang *et al.,* 2003). This means that edible insects may help mitigate the health problems related to iron and zinc deficiency which is prevalent among women of reproductive age and children in developing countries (Mwagi *et al.,* 2018; Van Huis *et al.,* 2021).

In that vein, international organizations such as the United Nations have been promoting the use of edible insects to help address food insecurity in some regions (Van Huis *et al.,* 2013). While entomophagy has been practiced and continue to form part of traditional diets for people in Asia, Africa and Latin America, consumption of edible insects has been absent in the European and American food cultures from the 19th Century because of negative attitudes and perceptions (DeFoliart, 1999; Olivadese *et al.,* 2023). Among the leading causes of the rejection of entomophagy in the West is what is known as the disgust factor. Disgust is defined as a food related emotion and revulsion at the prospect of oral incorporation or ingestion of offensive objects (Rozin and Fallon, 1987). Food neophobia, defined as the reluctance to ingest unfamiliar or novel foods (Van Huis and Rumpold, 2023), could also contribute to low acceptance of edible insects especially in communities with no culture of entomophagy. In cases where insects are consumed in America and Europe, the motivation is that they are consumed as novelty snacks in specialized restaurants (Melgar-Lalanne *et al.,* 2019; Lange and Nakamura, 2021). The negative attitude of the global north towards entomophagy has arguably resulted in the neglect of edible insects as food and economic resources in some regions globally (DeFoliart, 1999; Looy *et al.,* 2014).

People in Africa, Asia and Latin America are currently the largest consumers of edible insects (Jongema, 2014; Omuse *et al.,* 2024) where insects are consumed as a food supplement or as main constituents of the diet (Van Huis, 2003; Yen, 2015; Bermúdez-Serrano, 2020) or as alternative food in lean times (Costa-Neto, 2016). In the northwest Amazon, insects provide up to 7% of total protein intake throughout the year for local people and reach a peak level of 26% between May and June when edible insects are readily available (Costa-Neto, 2016). Nonetheless, the region has witnessed a declining trend in insect consumption, because the majority of the urban population associate entomophagy with poverty and shame (Katz, 2011; Costa-Neto, 2016). The Asian continent has 932 species of recognized species of edible insects, making it the leading content with the highest number of recognized species of edible insects (Omuse *et al.,* 2024). In that regard, various insect species are collected all year round from different habitats so that there is a steady supply of edible insects (Van Huis *et al.,* 2013).

In the Asia-Pacific region, the degree to which entomophagy is accepted is determined by dietary needs, cultural considerations and availability of edible insects (Meyer-Rochow and Chakravorty, 2013; Yen, 2015; Ghosh *et al.,* 2017). Despite low levels of entomophagy in Australia and New Zealand, due to industrialization and the influence of European food cultures, insect foods are an important part of the health and food culture of the Australian Aborigines (Yen, 2015). In Africa, about 1500 edible insect species ranging from *Lepidoptera* (caterpillars), *Orthoptera* (locusts, grasshoppers, crickets), *Blattoptera* (termites), *Hymenoptera* (ants and bees), *Coleoptera* (beetles), *Heteroptera* and *Homoptera* (bugs) are consumed and form part of an important source of food (Malaisse, 2005; Van Huis *et al.,* 2013; Raheem *et al.,* 2018; Ebenebe *et al.,* 2020; Matandirotya *et al.,* 2022; Omuse *et al.,* 2023), especially in times of food shortages or when the availability of other protein sources such as fish and game declines (Van Huis *et al.,* 2013). For example, 96 insect species are eaten in the Central African Republic where locusts and grasshopper are the most consumed, followed by caterpillars, termites and cicadas (Roulon-Doko, 1998). In southern Africa caterpillars are the most popular and widely consumed insect species.

However, not all edible insects are viewed the same as there are some that are more popular and fetch high market prices as compared to others, hence causing variations in the consumption of insects among different groups at national and community levels (DeForliat, 1999; Ramos-Elorduy, 2009; Jongema, 2014; Ghosh *et al.,* 2018). For example, about 200

insect species are consumed in Thailand alone, 35 species in Papua New Guinea and 7 species in New Zealand (Hanboonsong *et al.,* 2013; Omuse *et al.,* 2024).

In Africa, countries dominating in entomophagy are Cameroon, Central African Republic, Congo, DRC, Nigeria, South Africa, Uganda, Zambia and Zimbabwe (Adeoye *et al.,* 2014; Kelemu, 2016). This shows that entomophagic practices may also vary depending on the abundance and rate of reproduction of edible insect species, life cycle stage, the seasons when edible insects are available and the knowledge and perception that local people have about the different species, their taste, preparation and consumption (Chakravorty *et al.,* 2011; Ghosh *et al.,* 2018; Meyer-Rochow *et al.,* 2021). This may indicate that different insect species may contribute differently to food security or their role within the food basket.

Additionally, knowledge gaps exist on how wild harvested edible insects could be utilized to help improve rural livelihoods, as focus has been mainly placed on farming of edible insects for commercial purposes such as use as feed in the poultry and fisheries sector. Because of the declining wild populations of many edible insect species, the emphasis now has been placed on breeding edible insects in controlled spaces where insects' living conditions and diets are controlled (Van Huis, 2020; Meyer-Rochow *et al.,* 2021). For example, crickets are farmed in Thailand, Vietnam and Laos (Hanboonsong *et al.,* 2013; Van Huis *et al.,* 2013). Some advantages of insect farming include low carbon footprint, water resource use efficiency, and reduced land use (Van Huis and Oonincx, 2017). However, farmed insects may not have the same taste and quality as wild harvested insects. The focus on farming insects in controlled environments may mean that farmers need to have certain knowledge and skills to derive benefits from breeding edible insects. Further, commercial exploitation of edible insects requires financial investment and training, and many people in sub-Saharan Africa do not have this capacity because of inadequate financial resources and high illiteracy. This means that harvesting of edible insects by rural communities generally takes place at a local and community level and in natural and wild ecosystem contexts (Swierk, 2014; Barbier, 2019).

Other than food (DeForliat, 1999; Van Huis *et al*., 2013), wild insects provide different cultural and supporting services (MEA, 2005), an indication that wild edible insects provide a variety of benefits that underpin human wellbeing. Contrary to Papastavropoulou *et al.* (2022) who suggested that edible insects are solely consumed as an emergency food in lean times, various global and regional trends may suggest that other factors that may influence edible insect

utilization may include traditional knowledge (Ghosh *et al.,* 2018; Hlongwane *et al.,* 2021), culture (Egan, 2013; Yen, 2015) and personal choices (Ghosh *et al.,* 2018).

In some parts of the world, some species of edible insects are sold at local markets but their prices are often higher than that of conventional animal meats (Meyer-Rochow *et al.,* 2021). For example, in South Korea, the retail cost of 100 g of larvae of *Gryllus bimaculatus* (crickets), *Tenebrio molitor* (mealworms) and *Protaetia brevitarsis* (beetles) was US$8-$80 which was higher than the price of pork (Ghost *et al.,* 2017). In Thailand, the price of 1 kg of cricket was US$6 while that of pork was US$4.5 (Ghost *et al.,* 2017). In South Africa, some caterpillar species cost about R73 per kilogram compared to about R53 for minced meat (Egan, 2013) while in Latin America, the cost of insects exceeds the cost of many conventional animal meats (Yen, 2015). The high retail prices of edible insects may have contributed to the declining practice of entomophagy not only in industrialized countries like Japan and Korea but also in poor communities like the Nagaland in northeast India (Ghosh *et al.,* 2017). Therefore, entomophagy may not necessarily be treated as famine food in some communities but food of luxury. Additionally, collecting, processing and trading of wild edible insects may also be a livelihood strategy for some marginalized rural groups such as providing income and employment opportunities for people in Limpopo, South Africa (Egan, 2013; Hlongwane *et al.,* 2021). Studies present different reasons for insect consumption and show that the contribution of edible insects to food security varies widely among different groups within communities (Raubenheimer and Rothman, 2013; Van Huis *et al.,* 2013). This could indicate that there are complex and multidimensional societal, familial and cultural reasons that insect consumers may present.

2.2 Insects as food

Owing to food insecurities that many poor countries and communities face, it is argued that insects could play a significant role in food security and reduction of malnutrition. This is because insects contain essential amino acids and are a sustainable source of protein that is comparable to meat, fish, milk and eggs (Ghosh *et al.,* 2017; Van Huis, 2019; Kim *et al.,* 2020; Van Huis *et al.,* 2021, Kipkoech *et al.,* 2021; Van Huis and Rumpold, 2023). A study of eight frequently consumed insects in different parts of Africa found that insects were better sources of dietary protein compared to regular animal sources such as beef, chicken and pork (Kewuyemi *et al.,* 2020). For example, protein levels in *Cirina forda* and *Gonimbrasia belina* (caterpillars) were 69%, 35% in *Encosternum delegorguei* (stink bugs), 71% in *Gryllus*

assimilis (crickets), 31% in *Macrotermes bellicosus* (termites), 52% in *Oryctes rhinoceros* (palm beetles) and 44% in *Ruspolia differens* (grasshoppers) (Kewuyemi *et al.,* 2020). In West Africa, a study showed high amino acid profiles for five commonly-eaten insects of *Cirina butyrospermi* (caterpillars), *Hermetia illucens* (black soldier fly), *Musca domestica* (house fly), *Rhyncophorus phenicis* (African palm weevils) and *Macrotermes bellicosus* (termites) (Anakware *et al.,* 2021). In East Africa, *Schistocerca gregaria* (grasshoppers), *Locusta migratoria* (locusts) and *Gryllus assimilis* (crickets) were shown to have high protein contents of 65%, 54% and 61%, respectively, with all relevant amino acids (Fombong *et al.*, 2021). In Zambia, a nutritional study of *Gonimbrasia belina and Gynanisa maja* (caterpillars), Ruspolia *differen*s (grasshoppers), and *Macrotermes falciger* (termites) found high protein content of 43–56%, fats of 10–43% and 385–810 kcal of energy (Siulapwa *et al.,* 2014*).* These studies highlight that edible insects provide sustainable and easy access to protein, thereby contributing to improved diets and undernutrition as they are mostly harvested from the wild at no or minimal cost.

However, not all edible insects of the same species are of equal nutritional value as this depends on environmental conditions, developmental stages, diet, sex, processing methods (Meyer-Rochow *et al.,* 2021) and the locations where insects are collected (Hlongwane *et al.,* 2022). For example, four different types of insect species (caterpillars, termite soldiers and termite alates) were procured from different markets in Vhembe district but reportedly sourced from Zambia, Botswana, Zimbabwe and South Africa show variations in protein and mineral content (Hlongwane *et al.,* 2022). The protein content in mopane worms sourced from South Africa was 64 g per 100 g compared to 64 g/100 g in mopane worms from Zimbabwe and Botswana, while the protein content in caterpillars from Zimbabwe was higher than those from other countries. This points to the possibility that different environmental factors such as habitats, chemical compositions of the plants that the edible insects consume or live on, soil chemical composition and climate may influence nutritional composition. However, Hlongwane *et al.* (2022) could not specifically state whether environmental conditions or method of collection, storage and preparation was the cause. Similarly, Kewuyemi *et al.* (2020) and Hlongwane *et al.* (2022) did not indicate the life stages of the listed edible insects, especially given that the quality of protein may dependent on the developmental stage and preparation methods used.

On the other hand, due to high micronutrients and protein content, insect foods may not be the ideal alternative foods in communities struggling with the problems of over nutrition.

Additionally, the variations in nutritional content between and within insect species means that consumers may need to have the right nutritional information or insect species for them to achieve their nutritional needs. However, such information may not be readily available especially that most insect foods sold in local markets both in developed and developing countries lack correct labelling (Yen, 2015; Meyer-Rochow *et al.*, 2021).

Nutritional variations between and among edible insect species may pose a challenge in nutritional value to people as they may not always supply optimal nutritional benefits. Further, lack of availability of insects during certain periods of the year may hinder their contribution to food and nutritional security. Despite the FAO promoting insect farming as a sure way of ensuring insect availability and sustainability, farmed insects may not readily be accepted in communities where insects primarily collected from the wild are often embedded in traditional cultural practices and religious beliefs.

Another area of concern is the potential of insects to transmit diseases through pathogens such as bacteria and viruses which they could have acquired from their environment (Van Huis, *et al.,* 2016; Tang *et al.,* 2019; Murefu *et al.,* 2019). For example, *Encosternum delegorguei* (stink bug) which is consumed in Southern Africa discharges a defensive chemical that stains the skin and affects eye sight (Dzeferos and Witkowski, 2014). Some species of grasshoppers, specifically *Zonocerus variegatus*, eaten in West Africa are known to secrete some chemicals which are repulsive to humans (Idowu and Idowu, 1999). This means that if biological and chemical hazards are not properly removed during preparation for human consumption, edible insects could be dangerous. There may also be need for protective gear when collecting edible insects which may not be easily available especially to collectors in rural areas as these may be costly as well as need for proper cooking methods to remove potential pathogens

2.3 Food characteristics

Different communities globally exhibit different reasons for insect consumption including nutritional value (Meyer-Rochow and Chakravorty, 2013; Ghosh *et al.,* 2018), medicinal properties (Meyer-Rochow, 2017), availability, taste and culture (Ghosh *et al.,* 2018). This shows that the consumption or non-consumption of insects may result from different factors in combination for people with different backgrounds. Several studies show that food characteristics such as taste, flavor, appearance, color and palatability may influence consumer preference (Sijtsema *et al.,* 2002; Ghosh *et al.,* 2018; Manditsera *et al.,* 2018; Wendin and

Nyberg, 2021; Meyer-Rochow *et al.*, 2021). Appearance is one of the major factors influencing the consumption or rejection of edible insects (Wendin *et al.*, 2021; Simeone and Scarpato, 2021). For example, despite several species of *Chaoboridae* (Diptera) in the Lake region of Lake Victoria in Kenya, the Luo people prefer consuming *Chaoborus* spp. locally referred to as Otar and *Chironomus* spp. also locally known as mang'a or oteng', while Chaoborids of other colors were collected elsewhere (Ayieko and Oriero, 2008). *Chaoborus* was preferred because it was finer in texture and had a unique aroma (Ayieko and Oriero, 2008). In Italy, willingness to consume insects was determined by the way in which insect products were presented: the bigger the size of edible insects, the more unwilling people were to eat them (Balzan *et al.*, 2016). Consumers were also more willing to consume insects when in powder form or as lollipops, biscuits and cheese.

In South Korea, about 51% of people did not consume edible insects because of their shape, taste and smell, which caused disgust (Bae and Choi, 2020) while in Portugal acceptance to consume insects was greater if transformed into other food products (Florenca *et al.*, 2021). In South Africa, freshness, presence of legs, cleanliness, species type and oil content were considered before consumers would purchase termites (Netshifhefhe *et al.*, 2018) while in Kenya, long bodied termites were highly preferred and in demand than other elates (Alemu *et al.*, 2017).

This shows that quality and appearance are also important factors in deciding whether or not to eat insects. Other than appearance, factors such as taste, texture, context, exposure and nutrition are also important (Manditsera *et al.*, 2018; Ghosh *et al.*, 2018; Wendin *et al.*, 2020; Wendin and Nyberg, 2021). For example, a comparison of food characteristics that motived consumers in urban and rural Zimbabwe found that 95% of urban and 92% of rural residents were motivated to consume insects because of their taste. Texture accounted for 76% of preferences in urban and 79% in rural areas; appearance was 54% in urban and 76% in rural areas; smell was 56% in urban and 71% in rural areas; safety was 61% in both urban and rural areas; and nutrition was 88% in urban and 60% in rural areas (Manditsera *et al.*, 2018). This evidence shows that food characteristics influence the likelihood of different insect species being utilized as food. However, Manditsera *et al*. (2018) did not indicate whether there were different methods of preparation or food characteristics preferred by different genders and age groups.

Certain insects may be preferred as larvae or adults due to their nutritional value, palatability or desired characteristics when they enter certain developmental stages. For example, members of the Nyishi and Galo tribes in India prefer consuming larvae of dragon flies and damselflies to adult flies, and prefer adult grasshoppers, crickets and cicada, while insects such as bees, hornets and wasps are eaten at all developmental stages (Chackravorty *et al.,* 2013). This was because palatability and taste change between stages. Further, the developmental stage of the insect also determines whether it would be boiled, roasted or fried. For example, in India, long horned grasshoppers roasted or fried in oil are usually fed to children and older people (Chackravorty *et al.,* 2013). This means that the purpose for consumption influences the insect preparation methods and the types of people who would consume insects prepared in a certain way. Generally, several examples cited above show that if insects are to be accepted as food by different people and communities, there is need to maintain the quality of nutrition, sanitation and hygiene of the product (Chakravorty *et al.,* 2011; Egan, 2013; Mozhui *et al.,* 2017; Ghosh *et al.,* 2017; Meyer-Rochow *et al.,* 2021).

2.4 Edible insect preparation

Studies have shown that there is no single method of insect preparation as they can be consumed in stewed, dried, grilled, roasted or boiled forms (Van Huis *et al.,* 2013; Ghosh *et al.,* 2018; Manditsera *et al.,* 2019; Hlongwane *et al.,* 2022; Kipkoech *et al.,* 2023). Insect preparation methods may vary according to the consumer's needs and preferences. For example, frying and roasting are mostly used to prepare insects in northeast India because these methods are said to enhance taste of insects unlike boiling and baking (Chakravorty *et al.,* 2011). In Kenya, consumers preferred fried insects while in Uganda and Tanzania, salted, boiled, smoked and deep fried grasshoppers in seed oil were the most preferred (Mmari *et al.,* 2017).

Consumption of edible insects in cooked form improves sensory quality taste, shelf life and safety (Meyer-Rochow *et al.,* 2021). Food preparation methods also contribute to variations in the biochemical composition of edible insects including enhancement of nutrition (Manditsera *et al.,* 2019; Hlongwane *et al.,* 2022). For example, boiled mopane worms to which salt was added looks darker than when it is not added (Hlongwane *et al.,* 2022). The darker appearance may be less acceptable to consumers compared to the ones that look lighter. However, salt addition to mopane worms may help improve flavor (Hlongwane *et al.,* 2022). Nonetheless, Hlongwane *et al.* (2022) did not consider other edible insect types or preparation methods. In

Sudan, boiling, frying and sun-drying are some of the methods used to prepare locusts, or they are eaten raw (Mohammed *et al.,* 2015). The preparation methods for insects are similar to animal, poultry or fish cooking methods, in which the majority households already have skills. However, Mohammed *et al*. (2015) did not indicate why consumers preferred edible insects to be prepared in the way they did. The methods used may depend on the type of insect and may lead to other desirable food characteristics such as improved taste, palatability and extended shelf life (Meyer-Rochow *et al.,* 2021). In addition, certain preparation methods can help eliminate toxic components in edible insects to enhance safety (Klunder *et al.,* 2012; Kipkoech *et al.,* 2023). For example, fermentation can improve the bioavailability of nutritious and health-promoting components in edible insects as well as improving shelf life (Kewuyemi *et al.,* 2020). Locusts can be blanched, ice cooled and oven dried to give greater nutritional content to edible insects that were fried or boiled (Fombong *et al.,* 2021).

Processing methods may influence food and nutrition security outcomes. For example, boiling caterpillars results in the highest retention of protein and mineral content rather than frying (Hlongwane *et al.,* 2022). Drying and toasting grasshoppers significantly reduces protein digestibility while the same preparation method does not affect termites (Kinyuru *et al.,* 2010). Boiling of edible beetles results in decreased protein content (Manditsera *et al.,* 2019) while frying of mopane worms decreases mineral content (Hlongwane *et al.,* 2022). In Zambia, a marked difference in amino acids among four different edible insects was found, partly due to processing methods that included drying and frying (Siulapwa *et al.,* 2012). Boiling, toasting and drying crickets, grasshoppers, black soldier flies and moths of a cotton leafworm decrease their fat content by 0.8–51%, while toasting, boiling, oven drying and sun drying increase protein content by 1.2–22% in the order of the listed preparation methods (Nyangena *et al.,* 2020). On the other hand, boiling of beetles and crickets results in loss of protein and decreased digestibility and mineral accessibility (Manditsera *et al.,* 2019). Different processing techniques may yield implications on the overall nutritional value of insects. As such, consumers need to know how to prepare different types of insects in different ways in order to acquire the desired protein, energy and micronutrient properties. Certain preparation methods could be costly to some rural residents who have no means of ice cooling and oven preparation due to limited access to electricity or appliances such as refrigerators. Additionally, although fermentation is a common technique used in many African communities to preserve plant-based food (Nyangena *et al.,* 2020), this may require special culinary skills.

Although studies indicate that certain preparation methods can lead to nutritional enrichment (Siulapwa *et al.,* 2012; Manditsera *et al.*, 2019; Nyangena *et al.,* 2020; Meyer-Rochow *et al.,* 2021; Hlongwane *et al.,* 2022), some preparation methods may also be influenced by taste or dietary preferences, socioeconomic status, availability of edible insects, and time and energy spent to prepare them. Insect processing methods may also differ according to culture, geographical regions and insect species. For example, termites are mostly eaten fried, sun-dried or smoked in most geographical locations but in Uganda they are steamed in banana leaves (Van Huis *et al.,* 2013). Although many studies have shown how different preparation methods affect insect nutritional values (Siulapwa *et al.,* 2014; Manditsera *et al.*, 2019; Nyangena *et al.,* 2020; Anakware *et al.*, 2021; Fombong *et al.*, 2021; Hlongwane *et al.,* 2022), it is unclear how alternative preparation methods could improve the acceptability of edible insects among different demographic groups. Further, there is lack of adequate information on how storage is likely to affect insect flavor, taste and texture as storage conditions may be critical to prevent the deterioration of insects.

Studies in locations with different cultural and economic dynamics may not be easily compared, hence their findings may not be an indication of how insect resources are used in rural societies (Madibela *et al.,* 2007; Van Huis *et al.,* 2013; Manditsera *et al.,* 2019). It is therefore important to understand how residents in the study area (Kaindu) prepare edible insects and the influences on their decisions. Table 1 summarizes several traditional methods of cooking some insects in African rural communities.

Table 1. Traditional methods of cooking commonly consumed insects and the motive for the preferred method(s).

Insect type/Product	**Cooking method(s)**	**Reasons or motive for cooking in that manner**	**References**
Encosternum delegorguei **(Stink bugs)**	Boiling, blanching, steaming	Nutritional value, safety, texture, flavor, relish	Nonanka, 2009; Dzerefos and Witkowski, 2013: Nyangena *et al.,* 2020
Ruspolia nitidula and Ruspolia differens **(Grasshoppers)**	Pan-fried, sun-drying, toasting	Texture, safety, taste, relish, snack	Agea, 2008; Chakravorty *et al.,* 2011; Fombong *et al.,* 2017; Mmari *et al.,* 2017
Schistocerca gregaria **(Locusts)**	Pan-fried, boiling, smoking, toasting, sun-drying	Nutritional value relish, snack, safety, taste, texture	Mohamed,2015; Mmari *et al.,* 2017

***Gryllus bimaculatus* (Crickets)**	Boiling, blanching, steaming, sun-drying	Taste, flavor, texture, nutritional value, relish. safety,	Chakravorty *et al.*, 2011 Melgar-Lalane, 2019; Kipkoech *et al.*, 2021
Macrotermes falciger and Carebera vidua (termites)	Pan-fried, toasting, sun-drying	Taste, flavor, texture, nutritional value, relish, snacks, medicinal value	Ayieko *et al.*, 2012; ; Hlongwane *et al.*, 2022; Kipkoech *et al.*, 2023
***Gonimbrasia belina, Gynanisa maja* (Caterpillars)**	Boiling, blanching, steaming, pan-fried, sun-drying, toasting	Safety, taste, flavor, texture, nutritional value, relish, snacks, medicinal value	Manditsera *et al.*, 2018; Melgar-Lalane, 2019; Hlongwane *et al.*, 2022
Honey	Raw	Botanical origin, color, taste, flavor, medicinal value, health	Anyanje, 2011; Elzaki and Mohammed, 2012; Tola *et al.*, 2020

2.5 Environmental and financial benefits of edible insect farming

A major global debate surrounding the use of edible insects is that insect-based diets could help achieve environmentally sustainable food security as insects have a faster growth rate, higher feed-to-food conversion efficiency, and lower emission of greenhouse gases compared to other foodstuffs smaller environmental footprint (Van Huis and Oonincx, 2017) and could be used as a means to manage diet related problems, particularly obesity (Lange and Nakamura, 2023). For example, greenhouse gas emissions by insects such as locusts, and mealworms are 100x lower compared to livestock (Oonincx *et al.*, 2010). Crickets require less than 2 kg of feed for every 1 kg of body weight gain, whereas chickens require 2.5 kg of feed, 5 kg of feed for pork and up to 10 kg for beef to achieve an increase in body weight by 1 kg (Deroy *et al.*, 2015). This means that the high feed conversion efficiency reduces production cost and increases profit margins for insect farmers. Further, since edible insects of different types are consumed at different stages of their life cycles, reared insects may be available at most times of the year. Additionally, insects require less land and water compared to livestock (Van Huis *et al.*, 2013). For example, about 2300 litres of water is required to produce 1 kg of chicken, 3500 litres for 1 kg of pork and 22 000–43 000 litres for 1 kg of beef (Pimentel *et al.*, 2004), while the amount of water needed to produce 1 kg of insects is considerably lower (Van Huis *et al.*, 2013). This shows that edible insects can reduce environmental pressure in terms of water and land demand.

In terms of consumption, up to 80% of insect body parts are consumed as compared to 55% in chicken and pigs and 40% in cattle (Nakagi and DeFoliart, 1991). This may mean that there is

less wastage. Additionally, the prices for most edible insects in many parts of the world including Africa are lower than for beef, poultry and pork (Lange and Nakamura, 2023). For example, in Zambia the average price of insects like caterpillars, grasshoppers and flying termites per kilogram is less than the price of beef and chicken (Siulapwa *et al.*, 2014). This means that edible insects could be used as a cheaper and more sustainable source of protein in communities with protein deficiencies.

Since edible insects are mainly collected from the wild, mostly forested and agricultural areas in many Africa communities, there could be different environmental and socioeconomic dynamics involving reared and wild edible insects. Therefore, it is important to know how environmental and human factors affect wild insect populations and how insects help maintain health ecosystems, particularly the forests and agricultural ecosystems from where most wild edible foods are collected.

2.6 Challenges concerning the use of edible insects as alternative food sources

The practice of entomophagy has faced social and cultural stigma in many parts of the world, leading to variations in how different societies value and perceive edible insects (Olivadese and Dindo, 2023). For example, in the food cultures of many European societies there is stigma against entomophagy because insects are widely regarded as food for the poor and also treated with the sense of disgust (Yen, 2010; Costa-Neto; 2016; Tan, 2017). For example, a study of consumer acceptance of edible insects between Thai and Dutch consumers showed that in Thailand entomophagy was widely accepted as part of local diets while in the Netherlands it was rejected (Tan, 2017). Koreans are more willing to consume insects as human food than Ethiopians despite the fact that Korea is more industrialized and developed (Ghosh *et al.*, 2020). This shows that lack of cultural exposure or traditional knowledge creates challenges for insects to be widely accepted as food. In Wakiso district in central Uganda, acceptance of entomophagy was low compared to Adjumani district in northern Uganda because of the local aversion of people in some areas to some edible insect species (Olum *et al*., 2021). In Nigeria, 45% of the young people that used to consume insects no longer did so (Ibitoye *et al.*, 2021). This shows that people's dietary preferences or choices change with time or as they become older and as their socio-economic status changes.

Entomophagy may further be hindered in some regions because of the nutritional transitions in many communities globally due to economic and social development, food neophobia, disgust,

and lack of experience with certain insect species (Ghosh *et al.*, 2018; Van Huis *et al.*, 2021). The seasonal availability of insects harvested from the wild makes it difficult for consumers to access them consistently when not in season. For edible insects to be integrated into people's diets, they have to be available throughout the year. Additionally, the high local demand and low supply of edible insects make them an unlikely alternative to conventional animal protein because they may not be readily available or affordable. Collection of some insect species from the wild, and agricultural lands may also destabilize some ecosystem services such as pollination and pest control (Losey and Vaughan, 2006).

For edible insects to significantly contribute to food security and livelihoods, they need to be farmed in commercial quantities rather than just from the wild (Gahukar, 2016). Large scale insect farming would require feed, energy, processing and transportation infrastructure which may not be readily available in many communities. Food safety and other hazards associated with insect farming and consumption is of major concern currently. Mass production of edible insects may lead to zoonotic infections to humans, as is the problem with the mass production of other animals (Slingenbergh *et al.,* 2004). Insects collected in the wild may be infected with pathogenic micro-organisms such as bacteria, fungi, and protozoa (Klunder *et al.*, 2012). For example, in Nigeria, pathogenic bacteria were found in beetles (Banjo *et al.,* 2006) and in Botswana caterpillars were contaminated with fungi and mold (Mpuchane *et al.*, 2000) Additionally, edible insects may lead to allergies as well as chemical and biological hazards by contamination where they are found in agricultural areas where use of pesticides and other chemicals is prominent (Murefu *et al.,* 2019). This may mean that commercial insect products should include information labels; however, these products are mostly sold in the streets and traditional markets where quality assurance controls are nonexistent. Additionally, research into the potential risk of insect zoonotic transmission to humans is inconclusive and vague, and so knowledge about the safety of insect consumption is still limited and it may be difficult to attribute low insect utilization particularly in developing countries to such concerns (Slingenbergh *et al.*, 2004; Murefu *et al.*, 2019).

2.6.1 Perceptions and attitudes

Despite the numerous nutritional, health and environmental benefits that insects present, their acceptance in many societies across the world is low (LaBarbera *et al.*, 2020). For example, in the Laos and Thailand, there was a decline in the practice of entomophagy in rural areas

especially among young people because entomophagy was perceived as not being modern (Müller, 2019). In Kenya entomophagy is declining fast due to changes in eating habits and preferences (Kusia *et al.,* 2021). This is attributed to the fact that insect-based diets are perceived as a radical departure from current food traditions of modern societies (Fasanelli *et al.,* 2020). For example, in developing countries where entomophagy used to be common, a decrease has been noted and this has been attributed to decreased knowledge of preparation of edible insects in local communities and unavailability of edible insects (Meyer-Rochow and Chakravorty, 2013; Looy *et al.,* 2014; Ghosh *et al.,* 2018). The tendency to abandon entomophagy especially among young people in developing countries has also been attributed to the viewpoint that entomophagy is associated with primitiveness and is not accepted in European and American food cultures (Van Huis and Vantomme, 2014; Costa-Neto, 2016). This decrease in entomophagy could threaten its potential contribution to food security.

The negative attitude towards entomophagy in European countries unintentionally but negatively affects consumption of edible insects in developing countries (Looy *et al.,* 2014). This is because the fear, feelings of disgust and stereotypes expressed in developed countries dehumanizes consumers and ethnic groups that practice entomophagy in developing countries (Yen, 2009; Looy *et al.,* 2014). In turn, these negative attitudes may influence people's responses in preference to foods that are perceived to be socially acceptable (Looy *et al.*, 2014). Perceptions of people in the developing world concerning the diets and food cultures of people in European countries, such as the consumption of fast foods, may be viewed as conventional among the urban young. For example, in Zimbabwe a decline in entomophagy was noted among the urban young and this was mainly due to adoption of modern lifestyles (Manditsera *et al.*, 2018) and in KwaZulu-Natal, South Africa, a decline in entomophagy was attributed to the adoption of European diets (Hlongwane *et al.,* 2021).

However, it is argued that the decline in entomophagic practices in many parts of the world may not be entirely because of the influence of westernized food cultures but may also be due to local factors such as modernity at local levels and other transitions in dietary habits (Müller, 2019). For example, in Thailand, entomophagy is popular among the wealthy in urban areas, while in the Laos and Thailand, rural communities have experienced a decline in entomophagy (Müller, 2019). This shows that other factors such as modernity, retail price of some edible insects which are usually higher than the conventional sources of animal meats, and

demographic transitions at local level may be responsible for decreasing practice of entomophagy in several parts of the world at community level.

However, a negative attitude to edible insects may discourage people from valuing them for food, which means there has to be wider acceptance by communities before their use as a food source. For example, more than 65% of meat consumers in Belgium reject the idea of using insects as a meat alternative (Schösler *et al.,* 2012; Verbeke, 2015). In Siaya County, Kenya, there was low acceptance of entomophagy (Ochieng *et al.,* 2023) while in Botswana a declining practice of entomophagy among young people was noted (Obopile and Seeletso, 2013). These examples indicate that social acceptance and experience are important factors influencing the utilization of insects in society. This is because food practices shared by a group or community become part of socialization and cultural strategies, define social identities and distinguish them from other groups (Verneaus *et al.,* 2016).

Perceptions of people of different ages and cultural backgrounds can influence insect consumption patterns since societal perceptions are dependent on individual and group experiences, history and priorities (Sijtsema *et al.,* 2002). For example, insects maybe consumed as a result of physiological need (hunger), psychological need (food characteristics and preferences), and social need. Food characteristics such as appearance, taste and smell are important influences on perception (Sijtsema *et al.,* 2002).

Perception comprises objective reality (reality based on scientific knowledge of food), constructed reality (information shared through other medium), and other consumers' reality (information following experiences and judgment by other consumers) (Antonides and Raaij, 1999). Therefore, perceptions of edible insects are influenced by and individual's education, social environment and income. For example, stink bugs are consumed by the Vhavenda people in Limpopo, South Africa, who consider them as a delicacy (Teffo *et al*., 2007). Termites are widely and consistently consumed in KwaZulu-Natal, South Africa, while locusts are consumed less. In Limpopo, consumption of insects such as caterpillars, termites and grasshoppers are high with no significant differences across communities within the region (Hlongwane *et al*., 2021).

In Cameroon, Nigeria and in East Africa, and South Africa grasshopper (*Zonocerus* spp.) consumption is widespread but is uncommon elsewhere (Schabel, 2010). In Zambia, the green

milk weed locust *(Phymateus viridipes*) is consumed but not elsewhere (Malaisse, 1997). Insect species such as lake flies, termites, black soldier ants, and grasshoppers form part of traditional foods in western Kenya (Ayieko *et al.,* 2012). This shows that some species may be considered as traditionally important and consumed in one region, whereas they are not valued in other regions.

A cross-cultural comparative study of Chinese and Germans' willingness to consume insects found that Chinese people were more receptive and willing to consume whole insects such as crickets while Germans were more willing to consume processed insect-based foods (Hartmann *et al.,* 2015). Koreans were more willing to consume insects than Ethiopians (Ghosh *et al.,* 2020). This shows that there are cross cultural preferences across continents on the same continent and that entomophagy is likely to succeed if insects are incorporated into familiar foodstuffs especially in communities where the traditional consumption of insects is not part of the food culture.

Additionally, information on the benefits of edible insects may change people's opinions, behavior and attitudes (Verneau *et al.,* 2016). A study in Denmark and Italy found that people's willingness to consume insect related foods is related to the perceived benefits of these foods based on how these benefits are presented (Verneau *et al.,* 2016). In Kenya, the liking for buns made with Cricket flour increased after consumers were given the information (Pambo *et al.,* 2018) and the case was the same in Thailand where a preference for fermented rice noodles containing crickets increased after information was provided (Maw *et al.,* 2022). This shows that providing positive information about food may positively change consumer's perceptions and attitude because attitudes to food have an evaluative component as they deal with motives, ideas, and intentions (Sijtsema *et al.,* 2002). In that regard, there is need for effective advertising and the use of appealing phrases such as 'forget about the pork and put a cricket on your fork' or 'Mealworms and Spaghetti is food that makes you happy' (Meyer-Rochow and Jung, 2020; Meyer-Rochow *et al.,* 2021), to help change perceptions of consumers especially in communities where insects are shunned. There is also need to find suitable ways of presentation and packaging to promote the acceptability of insects.

Food preference studies highlight the influences on consumption patterns of certain food groups (Becker *et al.,* 2000; Sijtsema *et al.,* 2002; Gerbens-Leenes and Nonhebel, 2005). Consumption patterns refer to repeated arrangements in food consumption of a population

(Gerbens-Leenes and Nonhebel, 2005). For example, in Kinshasa (DRC) 8 million residents consume caterpillars both for nutritional value and taste while in Colombia and Venezuela, residents prefer specific insects to meat as mainstream diet items (Papastavroupolous, 2022). This shows that food preferences constitute one of the primary influences on food choice and its acceptance may depend on people's lifestyles.

Food related lifestyles may frame consumers' perceptions towards edible insects because food interlinks elements in which personal values influence the motive, cooking methods and views of food products, hence affecting consumers' behavior and food choices. For example, linking edible insect consumption to fitness trends and ecological sustainability can influence the acceptance of insects as food among consumers in northern Europe (Verneau *et al.,* 2020). Italians, who are more conservative food consumers, attach more importance to food security and meal choices than the Danish who are less interested in food to achieve life values (Piha *et al.,* 2018). In Zimbabwe, young people shun eating Giant jewel beetles (*Buptrestidae*) because they resemble dung beetles (*Scarabaeidae*) specifically *Eulepida anatine* and *Eulepida nitidicollis* (Dube *et al.*, 2013). The shows that only a fraction of edible insects may potentially contribute to a community's food security, depending on cultural preferences. It further shows that the names given to edible insects or how they are referred to may suggest the significance attached to certain insects by communities, hence influencing their social acceptability.

Other factors may include the disgust factor, defined as a feeling of revulsion for something, mostly of unpleasant appearance or smell (Tan *et al.*, 2015). Feelings of disgust strongly reflect a sociocultural viewpoint that is acquired and transmitted from one generation to another (Labarbera *et al.,* 2018). This could mean that people may be more tolerant or accepting of certain foods that form part of the local food tradition or culture. The discomfort or disgust factor has been identified as an important influence on the non-consumption of edible insects among different people (Van Huis *et al.,* 2013; Looy *et al.,* 2013; Wendin and Nyberg, 2021). For example, studies done in Germany (Orsi *et al.,* 2019), Italy (Sogari *et al.,* 2019) and Poland (Modlinska *et al.,* 2020) found a low acceptance of insects as a meat substitute due to psychological barriers such as disgust

Attitudes towards different types of insects may be influenced by factors such as familiarity, knowledge, age, gender and convenience. For example, a comparative study of willingness to buy insect products found that consumers in northern Europe were more positive towards insect

foods than those in central Europe, with the Netherlands and Belgium being pioneers in promoting insect foods on the market (Piha *et al.,* 2018). Attitudes towards different insect types may vary from one community or demographic to another (Hartmaan *et al.,* 2015), meaning that studies may miss out information on differences in food preferences at the community level. For example, Verneau *et al.* (2016) surveyed only young and educated participants and so it is difficult to generalize their results. Based on this, it is necessary to understand the attitudes and perceptions that different socio-demographic groups have towards edible insects, such as in Zambia.

2.6.2 *Cultural factors*

Food taboos, defined as unwritten dietary rules and regulations that declare certain food items fit and others unfit for human consumption, exist in many societies (Meyer-Rochow, 2009; Looy *et al.,* 2013). As a result of food taboos, certain food items or insects may be avoided, hence making society not to fully benefit from a wide variety of edible insects. In traditional societies, food taboos are mostly influenced by certain phases of human life cycle such as menstrual periods, pregnancy, child birth or funeral and certain religious and traditional beliefs (Meyer-Rochow, 2009). For example, in Uganda some tribes prohibit the consumption of raw grasshoppers because doing so was regarded as unethical and such an act was associated with stomach aches and diarrhoea (Mmari, 2017). The Luo people living along the Lake Victoria basin in Nyanza province in Kenya consume lake flies because they consider the fly has medicinal and cultural values (Ayieko and Oriaro, 2008).

The examples above show that certain food practices and restrictions may prevent certain subsections of the community from acquiring full economic and nutritional benefits because of such social rules. Furthermore, food restrictions may perpetuate the suppression of certain groups by dominant members of society or may promote inequality in the utilization or access to edible insects, especially where these can be used as economic or food resources in the wake of hunger and poverty.

Additionally, indigenous knowledge and traditional beliefs concerning different types of edible insects influence the levels of insect consumption in communities. For example, in southern Africa, about 83 species of edible insects are consumed of which caterpillars and termites are the most popular and widely consumed in many cultures and communities (Malaisse, 2005). The Mbunda people in Angola, Zambia, and Namibia consume 31 species of edible insects

(Kelemu *et al.,* 2016), the Ngandu people in the DRC consume 21 species (Takeda 1990), 96 species by the Gbaya people, the Bemba people in Zambia, DRC and Zimbabwe consume 30 species of edible insects (Kelemu *et al.,* 2016) and 27 species in Botswana (Obopile and Seeletso, 2013). In India, tribal communities found in the northeast consume more insects compared to those found in eastern and southern states (Gahukar, 2018). This shows that consumption of insects is an indigenous practice that forms an important part of food cultures in many African countries and communities and northeast India influenced by traditional beliefs and knowledge.

Despite entomophagy being traditionally practiced in African communities, the prestige of consuming insects has declined because of changing cultural values which has seen many people in developing countries switching to western diets (Ramos-Elorduy, 2009). For example, 95% of people in Limpopo Province still practice entomophagy whereas 28% of people in KwaZulu-Natal Province do so (Hlongwane *et al.,* 2021). This may show that food is sometimes not consumed for physical survival but as a form of cultural identity and with symbolic significance (Meyer-Rochow, 2009).

Enculturation, which refers to socialization into one's cultural group, could be a means by which individuals develop certain beliefs and values attached to food (Kim *et al.*, 2009). Social environment may be the primary source for food preferences, as where adults provide food for children in a home environment, and teach them what and how to eat. Enculturation is foundational to food choices and preferences because from birth people learn of what is accepted within different cultures (Burris and Rempel, 2004; Looy *et al.*, 2013). Learning early in childhood about food influences one's food choices later in life (Nicklaus, 2016), therefore food choices may be reinforced by social and cultural traits. This argument is applicable to the consumption of edible insects among people living in the same region. This is because what is perceived to be edible is defined and negotiated within cultural and social settings (Wendin and Nyberg, 2021) which may exclude some foods because they may be considered as unacceptable or taboo. This means that the choice of food may be influenced by the culture in which one is living or brought up, or that the ways in which people learn, interpret or integrate information about food is influenced by social interactions.

The beginnings of aversion or preferences in food are embedded in culture and upbringing, which exert effects on food habits (Meyer-Rochow, 2009; Looy *et al.,* 2014; Ruby and Rozin,

2019; Wendin and Nyberg, 2021). Culture and ethnic awareness about insects may increase their acceptability. This means that consumption patterns of edible insects may vary from one location to another or between different ethnic groups because of different cultures and preferences common to those groups (Teffo *et al.,* 2007; Makhado *et al*., 2009). Values given to insect species may depend on the experiences and familiarity that people have. For example, despite several types of *Chaoboridae* (Diptera) in the lake region of Lake Victoria in Kenya, Luo people mostly consume the phantom midges *Chaoborus* spp. locally known as Otar because of their finer texture, easy preparation and storage, and the belief that phantom midges are good for sick and weak children (Ayieko and Oriaro, 2008). This shows that such cultural stories and traditions about edible insects may help that group maintain its identity and traditional (indigenous) knowledge systems (Meyer-Rochow, 2009).

Cultural practices could further assign certain tasks and roles to specific genders or demographic groups in society, hence including or excluding certain people from acquiring the necessary knowledge and skills needed for insect utilization. For example, in Zimbabwe the collection, cleaning and processing of caterpillars was traditionally a preserve of women and children (Kozanayi and Frost, 2002). On the other hand, culture can help popularize the consumption of certain insects across societies. For example, although the culture of grasshopper consumption is indigenous to societies around Lake Victoria, this has spread to other communities in East Africa, particularly in Tanzania where *Ruspolia nitidula* grasshoppers are commercially available and widely consumed (Mmari *et al.,* 2017). The consumption of grasshoppers in this region has cultural significance and is a sign of prestige or respect to the persons being served (Mmari *et al.,* 2017). This shows that the way people understand, interpret and describe certain foods they come to know either from their home, the media or societal relationships are influenced by how such foods are presented or valued by these different actors. The social environment often becomes the primary source of food preference. For example, in Italy a study of social acceptance of insects as food between female millennials (aged 20-39) and female X-generation (aged 40-45) found that 65.7% of the millennials rejected the idea of insects as food while among X-generation 50% rejected insects (Fasanelli *et al.,* 2020). This suggests that knowledge, attitudes and beliefs about insects as food may be constructed through social interactions and that in every society there could exist cultural value gaps between generations. Further, globalization, urbanization and changes in media communication could influence dietary preferences and trends in some sections of local and global populations (Fasanelli *et al.,* 2020).

Social norms, whether written or not, concerning edible insect utilization exist in every society, and as such it is important to understand how acculturation or enculturation shape food consumption patterns and edible insect utilization among different generations or sectors within society.

This dietary shift along with a related progressive erosion of local traditions and customs (Ochieng *et al.,* 2023) contribute to low insect consumption especially amongst young people (Obopile and Seeletso, 2013; Manditsera *et al.,* 2018). Different consumption patterns of edible insects may indicate that they are valued differently and their contribution to food in society may differ from one locality to another depending on society's culture (Niassy *et al*., 2016). Thus, study of the processes of collection, preparation, storage and consumption could provide insight into cultural beliefs, perceptions, attitude and knowledge among different members of society and determine the contribution of insects to food security.

2.6.3 *Traditional and religious beliefs*

In many African communities, different ethnic groups have different food and dietary preferences because of cultural beliefs and restrictions that are related to oral traditions within these communities. A number of prohibitory rules concerning consumption of insects may depend on the person's sex, age and physiological status such as being pregnant or being one of twins (Van Huis, 2003; Meyer-Rochow, 2009; Looy *et al.*, 2013). For example, members of certain tribal groups in Malawi, Tanzania, Zimbabwe, Mozambique and Zambia are forbidden from eating winged termites because they are considered sacred, family totems and are used in traditional practices (Van Huis, 2003). *Brachytrupes* Servile 1838 (Crickets) are forbidden from being consumed by the Yoruba tribe in Nigeria because they do not have blood and the consumption of such is not allowed by Ogun, their iron god (Ayieko and Oriero, 2008). This shows that cultural beliefs or restrictions among different ethnic groups may affect the consumption of insects and thus any potential contribution to food security. However, some traditional beliefs can also encourage the consumption of insects depending on the physical condition of an individual, the purpose or reason for consumption, and the type of insect to be consumed (Ayieko and Oriero, 2008).

This shows that beliefs and myths surrounding certain insect species may hinder or promote their consumption among specific groups of people. It further indicates that entomophagy is

closely linked to traditional beliefs and myths. Additionally, religious beliefs may influence insect consumption especially in communities that have deep connections between different religious or traditional belief systems and the natural world. For example, in South Africa about 3% of people do not consume insects because of religious beliefs (Hlongwane *et al.*, 2020). In Ethiopia, 1% of the population accepts insects as human food while the majority do not because of prohibitions related to their religious beliefs (DeFoliart, 2002). In Zimbabwe, 21% of urban populations and 8.7% of rural populations are prohibited from consuming insects by their religion while 6.1% of urban and 22% of rural respondents were selective in the types of insects they eat because of their religious beliefs (Manditsera *et al.*, 2018). Among Christians, the practice of entomophagy is mentioned in the bible with given conditions on the consumption of insects. For example, it states that only grasshoppers, locusts and crickets should be eaten while all other types of winged insects that walked on four legs are to be considered unclean (Leviticus 11:21–23). In the New Testament, the bible cites *Schistocerca gregaria* (desert locust) and honey as the only insect and insect product consumed by the Prophet of God (Mark 1:6). In Islam, the Koran makes reference to insects such as *Orthoptera: Acrididae* (grasshoppers and locusts), *Hymenoptera: Apoidea* (bees), and *Blattodea: termitoidae* (termites). However, Islamic teachings specifically give permission to consume locusts, describing them as 'game of the sea' and 'Allah's troops' (Ying *et al.*, 2010; Sunaan Ibn Majah, 4.3219, 4.3222). In Judaism only four species of locusts are considered edible (Ying *et al.*, 2010). This indicates that religion may influence how or what types of edible insects are utilized by different societies or individuals (Chakravorty *et al.*, 2013; Dube *et al.*, 2013; Van Huis *et al.*, 2013). This means that religious restrictions may lead to underutilization of some edible insects, or may limit the ability of these resources in promoting food security and nutrition as certain groups may miss out on these benefits.

In Zambia, Christianity is the predominant religion accounting for about 96% of the population, of which 75% are Protestants and 20.2% are Roman Catholic. Muslims, Jews, Hindus and other religious groups account for 2.7% (CSO, 2010). In rural areas, some people may follow traditional belief systems or hold no religion; however, many people combine different doctrines and sects of Christianity and traditional beliefs in complex ways (IRF, 2019). This means that the consumption of edible insects might not be uniform. To understand the influence of religious beliefs on insect consumption patterns, one has to consider the different interpretations of insect uses among and within different religious denominations. Therefore, it is important to consider how religion has influenced insect consumption in rural Zambia and

how this may conform with or contradict traditional beliefs, and as well as how people balance or negotiate these belief systems.

2.6.4 *Availability factor*

The quantity or availability of edible insects may play a part in their consumption. For example, although entomophagy is generally high in Zimbabwe, people in rural areas consumed more edible insects than urban dwellers, in part because of their availability and easy access when harvested from the wild (Dube *et al.*, 2013**;** Manditsera *et al.*, 2018). *Chaoborus* spp. also referred to as Lake flies are consumed by all Luo communities that live within the Lake Victoria region including women and fishermen who mostly spend time around the lake (Ayieko and Oriaro, 2008).

These examples show that availability and accessibility of edible insect types may influence their consumption. The state of ecosystems in the region where wild foods are found may determine their contribution to the dietary needs of local people. For example, in the Masai region of Kenya consumption of wild insects contributes 6% of daily dietary needs (Kuhnlein *et al.*, 2009). In Karen, Thailand, locally sourced insects contribute 85% of the daily dietary needs. This is the same in Awajun, Peru, where locally sourced wild insects contribute 93% of the local people's dietary needs (Kuhnlein *et al.*, 2009). This indicates that tropical regions tend to have a higher proportion of locally sourced wild foods, including insects, compared to semiarid regions. Therefore, healthy ecosystems may contribute more substantially to dietary diversity, sustainable diets and food security in some communities than others.

2.6.5 *Socio-demographic factors*

The act of eating is not a one-off event but something that is influenced by social and cultural environments and contexts that cause people to choose the kind of food and amounts they would want to consume, how they do it, where they do it, and the rituals, traditions and ceremonies associated with it (Cheung and Moraes, 2016). Other than culture, socio-demographic characteristics such as age, gender, education and economic status may influence the consumption and choice of edible insects. For example, in Limpopo Province, South Africa, households with middle education levels were less likely to consume insects than households with lower education levels, similarly, those with higher education levels consumed less quantities of insects compared to those with lower education levels while households with lower income status consumed more quantities than those with higher income status (Egan,

2014). This may indicate that education and income levels of people may be important factors in influencing entomophagy in some communities. Education may further play a crucial role in determining the acceptance of edible insects in communities where insects are not consumed for cultural reasons because it may need adequate planning or sensitization due to different cultures.

In Brazil, women appeared to have a greater aversion to edible insects compared to men (Schardong *et al.,* 2019). In Italy, young males were more willing to consume insects than females and 24% of men preferred to eat insects whole while 14% of women preferred to consume insects through processed ingredients such as flour (Sogari *et al.,* 2019). In Italy young people were generally more willing to eat insects than older people while in Portugal young males with higher education levels were more willing to consume insects than women (Florença *et al.,* 2021). This may indicate that women were more conscious about the appearance, texture, and preparation of insects than men. Incorporating insects as ingredients in other processed familiar foods such as chocolates and biscuits may be a strategy used to increase insect acceptability in communities where insects do not normally form part of traditional food culture. However, this approach may not address the use of insects as foods in communities that are already financially challenged. To reduce prejudices and negative attitudes towards entomophagy, there is a need to communicate positive aspects of the practice. Schardong *et al.* (2019) studied the perception of Brazilian consumers on the safety and consumption of edible insects, but they did not indicate which age category in each gender categories consumed or did not consume insects more than the other or the consumption preferences of different age groups. Sogari *et al.* (2019) provide insight into the acceptance of insect consumption among young and adult Italian consumers but do not specify the type of insects that participants are willing to consume. Consumption of insects could be accepted or rejected even among people of the same age, gender or social group, therefore it is necessary to understand how different socio-demographics even in a community with a single cultural background perceive and value different types of edible insects.

In communities where insect consumption is a common practice, knowledge of entomophagy is passed between generations. However, age negatively affects willingness to consume insects (Sogari *et al.,* 2019). In Botswana it was noted that there was a declining trend of entomophagy among young people despite them having knowledge of edible insects (Obopile and Seeletso, 2013). Older people also had greater knowledge of edible insects but this knowledge differed

from one location to another. In Zimbabwe, the majority of insect consumers were older people and most of them were women (Dube *et al.*, 2013). In Mali, children forage and eat grasshoppers because this is a common cultural practice and they have been given specific ecological and traditional knowledge of grasshoppers (Looy *et al.*, 2014). This indicates that demographic factors may influence insect consumption among people of different ages due to their beliefs or perceptions. Different consumption patterns therefore indicate that experience, adaptation and knowledge influence how individuals and communities utilize and perceive different types of edible insects.

Limited utilization of edible insects amidst their abundance has seen debate emerge on how insects could be utilized for attainment of global sustainability goals such as poverty reduction, zero hunger, good health and well-being, if they were utilized effectively (Moruzzo *et al.*, 2021). Better understanding of insect ecosystem services could help change societal approaches to utilizing insect resources and an increased acceptance of insects as food in cultures where insects are not readily accepted, or help maintain knowledge and capacity to utilize insects in communities where entomophagy is declining. While factors that influence different consumption patterns between and among individuals have not been fully addressed, a lack of understanding of causal factors for insect consumption could have consequences for food security and cultural practices. This could further limit options for developing alternative sources of nutrition.

2.7 Livelihoods

Apart from ecosystem services, insects may be economically important as a source of livelihood to some harvesters (Egan, 2013; Sitanyehu, 2018) and for related enterprises in the value chain in informal and formal markets (Chamberlain *et al*., 2019; Tola *et al.*, 2020). Trade in edible insects has become important in mitigating poverty and a source of diversified income both locally and internationally (Tola *et al*., 2020). For example, global trade in wild edible insects accounts for about USD 57 billion annually (Losey and Vaughan, 2006). In sub-Saharan Africa, cross border trade between Botswana, South Africa and Zimbabwe involving mopani worms has grown, recording between 427 and 638 million Rand per year (Makhado *et al*., 2014; Sekonya *et al*., 2020). For example, in Limpopo Province, South Africa, trade in edible insects contributed about 3000 Rand per trader annually (Makhado *et al*., 2009). In Zambia, mopane worms contribute up to 62% of total income to rural households (Mbata *et al.*, 2002; Kalaba *et al.*, 2013). In Tanzania, trade in grasshoppers is not only conducted at a local level

but extends to markets in big cities (Mmari *et al.*, 2017). Laos and Cambodia export 700 tons of edible insects annually to Thailand due to high consumer demand, while 3 and 5 tons of caterpillars are imported annually into Belgium and France respectively from the DRC (FAO, 2004; Yen *et al.*, 2013). This shows that trade volumes and income generated from insect trade could help economic development in source communities as well as becoming a source of alternative livelihoods for people along the value chain who include insect harvesters/collectors, wholesalers, retailers and consumers. For example, retailers of longhorn grasshoppers earn up to USD 690 while wholesalers earn USD 2633 per season, and consumers benefit from purchasing the popular grasshoppers for as low as USD 0.20 per kilogram from USD 3 per kilogram during peak seasons (Odongo *et al.*, 2018).

Collection of different types of natural resources from the wild, such as edible insects, is important for sustaining rural livelihoods. Economic benefits that individual households realize from edible insects could be crucial for their survival. Marketing and commercialization of edible insects and their products have potential to create business opportunities. For example, in Thailand, the value chain involves traders who sell to wholesalers that in turn distribute insects to retailers or to larger supermarkets. As a result of this commercialization, the insect industry is well organized as it comprises of effective collection techniques, improved transport networks, storage of insects in frozen form for use during off-season and also export of insects as food (Yen, 2015).

However, the case is not the same in many African countries because economic stressors such as low consumer awareness, poorly organized value chains and lack of market infrastructure may prevent rural communities from benefiting from insect resources (Odongo *et al.*, 2018). For example, in Burundi, trade in edible insects such as longhorn grasshoppers happens only in selected district and village markets while in Uganda trade is done daily and in all market locations (Odongo *et al.*, 2018). This difference is because Uganda has relatively well-established collection, processing and preservation systems, as compared to Burundi. This indicates that the absence of established formal markets, especially in developing countries, may hinder the potential of edible insects to become a sustainable and reliable source of alternative household incomes.

When trade in edible insects is perceived as mostly localized and informal, it becomes difficult for various actors in the edible insect sector including policymakers to appreciate and harness

its economic potential. For example, despite edible insects being sold in village and urban markets in Uganda (Agea *et al.*, 2008) and Burundi (Odongo *et al.*, 2018), little is known about their marketing process, range of traded edible insects and supply chain actors However, such information is needed to create and manage a viable edible insect industry. Negative attitudes towards insect consumption may hamper their market expansion as well as prevent edible insects from being included in mainstream economic frameworks. Understanding the linkages between insects and ecosystem services, poverty reduction and sustainability, can help develop alternative economic activities to help improve the livelihoods of people in rural communities.

2.8 Ecological perspectives

Ecological systems play a pivotal role in food security because they are the bedrock for food production and dietary diversity, biodiversity in ecosystems which provide a source of nutritional adequacy (Clapp *et al.*, 2022). When evaluating the potential of utilizing edible insects as a sustainable source of food, it is important to consider the ecological status of some regions.

Edible insects that inhabit a variety of terrestrial ecosystems such as forests, agriculture fields and grasslands account for 88% of total insect species while 12% of insect species are found in aquatic ecosystems (Yen, 2015). In terrestrial ecosystems, 54% of insects feed on vegetation and tree branches, followed by omnivores that account for 18%, predators 8%, pollinators 7% and detritivores 6% (Yen, 2015). Owing to the fact that most terrestrial edible insects are plant feeders constituting about 54% (Yen, 2015), means that loss or reduction of host plants for herbivorous edible insect such as caterpillars may result in the reduction of caterpillars or an increase in the number of other competing herbivorous insects which may not be edible. For example, the first-instar larvae (caterpillar) of the moth *Hemijana variegate*, a popular edible insect in the Limpopo Province of South Africa, showed that its survival rate was high when it hatched at the time when host trees had fresh leaves as they were unable to feed on older leaves (Egan *et al.*, 2015). Additionally, there is also a danger of the proliferation of pest insects if predatory species such as dragonflies, some ant species, praying mantises and predatory water beetles are indiscriminately removed from ecosystems. This means that ecological disturbances can have cascading effects on other trophic levels or insect species that may result in an altered food web that may not be ecologically viable. Therefore, management of various ecosystems is of high importance if edible insects are to be considered as a sustainable source of food.

Insects provide a wide range of direct and indirect ecosystem services. This includes provisioning services such as food; supporting services like pollination; and regulating services like disease and pest control which sustain society and food production (Prather and Laws, 2018; Dangles and Casas, 2019). Thus, healthy ecosystems can help avoid any potentially cascading effects of ecological imbalance. For example, suitable host plants are needed to support the presence of caterpillars (Egan *et al.,* 2015). Countries in tropical regions specifically Brazil, China, DRC, India, Mexico and Thailand have the highest number of edible insects because they have shrubs, herbaceous vegetation and mixed closed forests (Omuse *et al.,* 2024). This means that loss or reduction of plant or insect species in some habitats may affect the functioning of a wide range of ecosystems and organisms.

Insect biodiversity is key to the sustainability of all ecosystems and their services that are important to crop production and food security (MEA, 2005; Prather and Laws, 2018), therefore, utilization of edible insects at large or commercial scale needs to consider possible ecological efforts of removing huge numbers of insects from nature

However, the increased use of pesticides in the food production process threaten the existence of some edible insects such as grasshoppers, locusts (Yen, 2015; Müller, 2019) and moths (Wagner *et al.,* 2021) that are found in agricultural areas where they are considered as pests. For example, the reduction of some edible insect species in Laos was attributed to the increase in the use of pesticides in effort to increase rice output (Müller, 2019). In South Korea, the mandatory application of insecticides in rice fields resulted in a huge decline in grasshopper population which was a traditional food (Yen, 2015). This shows that there is inherent danger that common pest species could become locally extinct, therefore, harvesting or collecting of insects considered as agricultural pests for human consumption or animal feed may prevent the loss of habitats required for insect repopulation.

Further, habitat destruction through bush clearance for field preparation and tree cutting for charcoal or bush burning may negatively affect ecosystems, insect populations and their availability. In some communities, some species of edible insects are incorporated within agriculture field systems by conserving habitats as deliberate measures to increase insect availability. For example, in Mexico edible grasshoppers are deliberately included within maize fields so as to harvest them when they mature (Payne and Itterbeeck, 2017). In Burkina Faso, caterpillars are harvested from maize fields and in Zimbabwe termites are harvested from

fields (Payne and Itterbeeck, 2017). The deliberate incorporation of edible insects into existing agricultural systems can help conserve the environment and natural habitats and help improve food security, where edible insects can serve as supplementary food to these communities.

Collection of edible insects from the wild, particularly from agriculture fields, as a measure of biological control, would be economically beneficial to farmers as they would spend less money to purchase chemicals but pick insects for food (Van Huis *et al.*, 2017). From an environmental perspective, the collection of edible insects can help replace the use of pesticides which causes suspicion of contamination amongst insect consumers (Looy *et al*., 2013; Tao and Li, 2018; Murefu *et al*., 2019). For example, in Mali grasshoppers which were once an important source of protein has seen its use dwindle for this reason (Looy *et al*., 2013). Without effective management of insect resources, there is a likelihood of local insect extinction and this may result in damage to ecosystem services and the food chain (Cardoso *et al.,* 2020). Little is known about the methods that indigenous communities apply to ensure better management of ecosystems and insect resources. However, some communities have specifically adopted practices that promote responsible use of edible insects (Van Huis and Oonincx, 2017). These include conserving host trees and vegetation, reducing bush fires, and selective trapping of insects (Delgado *et al*., 2012). For example, the traditional leadership in the Kopa area of Mpika district in Zambia, where caterpillars are harvested in abundance, regulates the harvesting of caterpillars by restricting the cutting down of host trees (Miombo woodland) (Mbata *et al.*, 2002). In Botswana and South Africa, some communities create community-based natural resource management systems such as community resource boards or community policing, commonly referred to as neighborhood watch groups, to help regulate, monitor and reinforce strategies to harvest caterpillars sustainably (Selaledi *et al.*, 2021). Local initiatives to regulate or manipulate the natural environment help address biodiversity and conservation strategy facing edible insects.

Increasing edible insect availability and predictability through community led conservation initiatives indicates knowledge about the value of edible insects by local communities. In communities where insect consumption is part of normal life, people may possess knowledge about the collection, processing and consumption of insects (Selaledi *et al.*, 2021). For example, although termites are harvested at the onset of the rain season in many sub-Saharan African communities, some communities in Kenya induce termites to emerge during dry season making them available to eat for the whole year (Jideani and Netshiheni, 2017). There is also

discussion on the ability to rear edible insects such as caterpillars (Ghaly, 2009), grasshoppers and crickets (Musundire *et al.*, 2021; Selaledi *et al.*, 2021) in controlled environments to increase their availability and productivity. Insect farming has also been intensified in countries like China (Chen, 2009; Chia, 2019) and Thailand (Yen, 2015) to increase insect availability and subsequently sustainability of the utilization of insects as food for humans and feed for animals and poultry.

Farming of insects for food or feed can help reduce the pressure on land, water and energy as insects have efficient feed conversion ratios compared to other sources of protein (Van Huis *et al*., 2013). However, insect farming requires capital investment and land where they could be farmed. Use of edible insects from the wild would be beneficial to indigenous communities as there is no financial requirement for this investment (Moruzzo *et al*., 2021). Protection and sustainable management of edible insects in the wild may result in the protection of other fauna and flora that inhabit a variety of ecosystems. It may also lead to reduced use of pesticides in agricultural ecosystems where insect populations have decreased. Expanding agriculture practices stand in conflict with efforts to protect biodiversity due to the fact that agriculture leads to habitat changes, pesticide use and pollution. To avoid such a dichotomy, there is need to develop a management and collection system that will guarantee sustainability of both community socioeconomic needs and protection of insect habitats and ecosystems.

2.8.1 *Sustainability challenges*

As population and demand for food increases, there is need to rethink alternative approaches for enhancing food and nutrition security in the developing world by embracing sustainable food sources. Sustainable foods are those with low environmental impacts, and are economically fair to producers and consumers (FAO, 2012). The use of edible insects as food sources fits within this context of sustainable diets (Van Huis *et al.*, 2013). However, the capacity of edible insects to contribute to the food mix has come under threat due to several sociocultural factors that may include negative attitudes towards edible insects and neglect of their nutritional value, and adoption of modern food cultures as a result of changing global systems. For example, a comparative study of insect consumption in Limpopo and KwaZulu-Natal provinces in South Africa, of males and females aged 18–75 with different education levels and occupations, established that 36% of respondents did not consume insects because of fear and discomfort, 27% because of the adoption of western food cultures, and 12% because of lack of knowledge. In Limpopo, 3% attributed non-consumption of edible insects to religious

beliefs and 2% to dislike (Hlongwane *et al*., 2021). In Zimbabwe, a decrease in consumption of edible insects was also noted because of the adoption of modern food cultures (Manditsera *et al*., 2018). This suggests that several interacting elements within food and nutrition system affect the utilization of edible insects.

To achieve sustainability in food security, it is important to consider the impacts of acculturation on local food systems and indigenous practices that sustain entomophagy. This will enable different actors to be protective and respectful of ecosystems, culture, safety and nutritional quality of edible insects and to develop economic and trading networks. The integration of such elements in food systems at local and global scales would help improve the sustainability of insect resources. For example, the traditional Mediterranean diet is widely considered as sustainable because of their diversity, variety of food practices and preparation techniques, commitment to culture and tradition, and low environmental impacts due to low consumption of animal products (Kuhnlein *et al*., 2009). This shows that the multifunctional nature of this particular diet puts food at the center of sustainability of people, environment and the economy.

Changing landscapes and destruction of habitats (Yen, 2015) expanding agricultural land (Müller, 2019; Wagner *et al.*, 2021) and deforestation (Musakwa, 2020) are also factors that contribute to declining practices of entomophagy. Decreasing insect populations and their uneven distributions are partially attributed to current food production systems that are considered unsustainable due to their environmental impacts (Tamburino *et al.*, 2020; Wegnar *et al.*, 2021). For example, decreased populations of mopane worms in Zambia (Mbata *et al*., 2002), grasshoppers and honey bees in Malawi, Zimbabwe and Kenya are attributed to forest and habitat degradation (Schabel, 2010). In Europe, the decline in butterflies is directly linked to changes in agricultural practices (Wagner *et al.*, 2021). Other than habitat destruction, climate change can have adverse effects on insect population and their availability. For example, caterpillars were observed to be only available for harvesting at the beginning of the good rainy season in South Africa and was not available in years with little or no rain (Egan *et al.*, 2015). This entails the need to understand climatic conditions that are necessary to support the development of caterpillars and other edible insects that are harvested from the wild.

Despite insects providing ecosystem services, they are also considered as a nuisance as agricultural pests, hence the use of chemicals such as herbicides and pesticides to control them

(Birch *et al*., 2011; Yen, 2015; Müller, 2019). However, chemical and pesticide use against insects has adverse effects on the environment including pollution and contamination which may make some insect species unsafe to eat (Murefu *et al*., 2019; Musundire *et al*., 2021). For example, in Thailand insects contaminated with pesticides are sold in markets (DeFoliart, 1999). In Kuwait, locusts supplied to the market were found to be contaminated with pesticides after crop fields were sprayed to control them (Saeed *et al.,* 1993). In Namibia, some consumers died after consuming caterpillars suspected to have been contaminated (Mbangula, 1996). Food safety is important if edible insects are to be used. Unhygienic handling of edible insects for human consumption has also contributed to their low consumption (Kachapulula *et al.,* 2018).

Contamination of edible insects is more likely in the supply chain if safety and storage facilities are compromised. For example, E-coli, yeast and zygomycetes were found in flying termites collected from the open market in Zambia (Mumbula *et al.,* 2022). The presence of these contaminants points to poor hygiene by various actors in the supply chain. Hygienic conditions from collection sites through to processing and storage are important for the safety of edible insects. To manage risks of contamination, edible insects need to be processed and prepared in certain ways such as boiling that may detoxify them. There is also a need to address methods of sorting and storage which are fundamental to the sustainable utilization of edible insects. Some studies have indicated safety (Murefu *et al.,* 2019; Musundire *et al*., 2021) and unhygienic conditions (Mumbula *et al.,* 2022) that lead to contamination but they have not indicated how these may affect the perceptions of consumers.

2.9 Policy gaps

Insect populations are declining in many parts of the world and threatening the sustainability of the varied ecosystem services that insects provide (MEA, 2005; Duffus *et al.,* 2023). While there are coherent policies in China, Brazil and Thailand regarding the safety, sustainability, trade and regulation of edible insects (Duffus *et al.,* 2023), policy frameworks to support the sustainable utilization of edible insects are still lacking or are fragmented and incoherent in many African countries (Niassy *et al.,* 2018; Musundire *et al.,* 2021). For example, a review of ten African countries found a lack of direct policies targeted at the management of insects as food (Musundire *et al.,* 2021). In South Africa (Niassy *et al.,* 2018), Nigeria, Botswana, Malawi, and Kenya (Musundire *et al.,* 2021), there is no national policy framework for edible insect utilization. In Zambia, there is also no specific policy or legal framework that guides the management of insect resources (Mbata *et al.,* 2002). For example, inventories of edible

insects and other edible invertebrates are biased towards certain insects with economic importance such as caterpillars. The current Zambian National Biodiversity Strategy and Action Plan (NBSAP-2) for the period 2015–2025 does not include specific reference to edible insects. This shows that there are gaps in existing food policies and framework that lack full appreciation of ecosystem services, specifically the role of insects as a transformative strategy to food security, conservation and sustainability.

Generally, no country in Africa has explicitly included edible insects in their food legislation or mentioned insects as food except for Botswana which recognizes caterpillars locally known as *phane* in its food laws (Grabowski *et al.,* 2020). However, edible insects are often regulated in the context of specific food laws, wildlife, and pest management frameworks, but the applicability of these regulations to insect resources depends on the country's legal definition of foodstuff or wildlife species and whether this includes edible insects. Like any other foodstuff, insects should to be regulated by governments to ensure their quality and consumer safety. An increasing demand for edible insects may lead to over-exploitation and environmental degradation in the absence of clear regulations of policies, and this may negatively impact on ecosystem biodiversity and services. For example, the declining population of mopane worms in Zimbabwe is attributed to increased commercialization and over-exploitation; and a lack of institutions and laws to regulate the use of mopane worms (Gondo *et al.,* 2010). Out of about 50 species of edible insects consumed in African communities (Musundire *et al.,* 2021), only caterpillars get full attention from traditional authorities for conservation, to the exclusion of other insect species such as flying termites and grasshoppers which are also harvested from the wild. For example, in Zambia the availability of edible insects, particularly caterpillars, is attributed to traditional harvesting practices that monitor the abundance of caterpillars and protect host plants and eggs from bush fires (Mbata *et al.,* 2002). Traditional conservation practices include some restrictions on harvesting to ensure insect sustainability. In the Central African Republic, communities coordinate to conserve caterpillar host trees such as *Entandrophragma cylindricum* from logging so as to promote the sustainability of caterpillars (Vantome *et al.,* 2004). In the DRC, communities create reserves or conservation areas where harvesting of caterpillars is restricted (Musundire *et al.,* 2021). This shows that local traditional practices and traditional leaderships have a key role to play in ecological management and conservation of insect species in the wild. However, this mainly focuses on caterpillars other than other insect types, which could lead to poor understanding of their significance to food security and livelihoods. Likewise, relationships

between the conservation and management roles of local traditional community leaders and other state institutional actors are often not clear cut and are not well described in policy documents. The integration of edible insects into national policy frameworks, current food system and mainstream economic activities is likely to motivate local communities to increase the utilization of edible insects and create robust value chains that would benefit a range of participants in the insect sector.

2.10 Conclusions

In conclusion, the literature shows that although edible insects are often neglected and perceived as nuisances affecting crops and human health, they potentially play an important role in minimizing food and nutrition insecurity in developing countries (FAO, 2004; Van Huis *et al.,* 2013; Ghost *et al.,* 2018; Van Huis and Rumpold; 2023). Factors such as culture, taste, religion, gender, socioeconomic considerations, dietary needs and availability of insects influence their consumption in different communities (Ghosh *et al,* 2018). Edible insects could contribute to livelihoods and food security if factors that affect their utilization were better understood and addressed, hence the motivation to investigate the role of edible insects and livelihoods in rural communities of Mumbwa district in Zambia.

Although entomophagy has traditionally been part of diets for many people in the developing world and in particular in Africa, this practice has been in decline due to social and climate change, and globalization. It is also influenced by acculturation, changes in local environmental conditions and ecosystems, and lack of knowledge of the dietary value of insects. Edible insects have potential to improve food security and a social safety net especially for rural communities in developing countries (Manditsera *et al.,* 2018; Hlongwane *et al.,* 2020). Edible insects are commonly a source of economic empowerment especially for women who mostly participate in its trade (Matandirotya *et al.,* 2022). This may also help achieve the SDGs aimed at reducing hunger, poverty, inequality, promoting good health and wellbeing, ecosystems sustainability and climate change. However, the potential of edible insects to improve food security is threatened by declining wild populations and lack of coherent or integrated policy frameworks (Niassy *et al.,* 2018; Musundire *et al.,* 2021). Ineffective handling of the safety of insects for human consumption has contributed in some instances to low consumption (Kachapulula *et al.,* 2018). There is need to safeguard insect resources holistically to ensure their sustainable utilization because of their environmental, socioeconomic and health benefits and their links to various issues that are at the center of human wellbeing (Figure 1). In Figure 1, various socio-

ecological components are identified and different arrows indicating the direction of relationship for each element and possible feedbacks. Although frameworks exist to manage protected resources such as wildlife, fish and forests through specific government departments, there is no specific remit for managing edible insect resources in Zambia. This omission may lead to over-exploitation of insect resources as they may be perceived as infinite and free open resources.

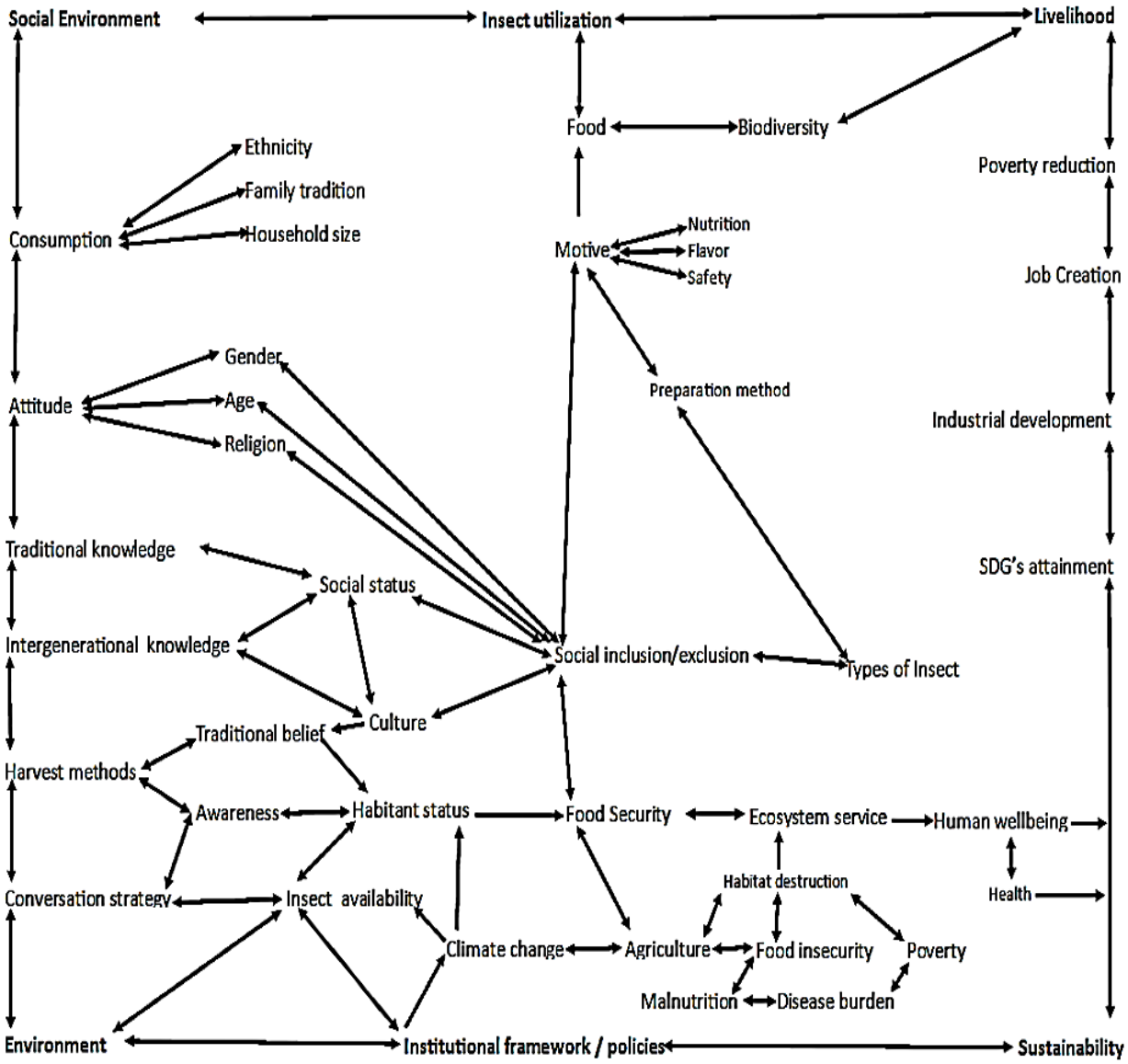

Figure 1. Model of how various individual, environmental, economic and social factors are interlinked and influence the utilization and sustainability of edible insects. Source: Knoot *et al.* (2010). In this diagram, bidirectional arrows indicate the relationship between many elements while the monodirectional arrow indicates a relationship with a single element.

Chapter 3: STUDY AREA

3.1 Introduction

This chapter describes the geology, topography, climate, ecosystems, and human and economic activities of the study area which is Kaindu chiefdom (14°58'S, 26°55'E) in Kalwanyembe ward of Mumbwa constituency, north of Mumbwa district in Central Province of Zambia (Figure 2). Kaindu is situated 200 km northwest of Lusaka, Zambia's capital city. Mumbwa's bordering districts are Kaoma of Western Province to the west, Namwala of Southern Province to the south, and Kasempa of North-Western Province to the north. The proximity of the study area to Lusaka and the presence of various natural resources make it attractive to investment in agriculture, tourism and mining. A good road network exists and connects the area to other towns and provinces. The Kaindu community has a variety of ecological environments including forests, rivers and grasslands and is endowed with a wide range of edible insects and other insect species in general. Birds, frogs, lizards, pangolins and bats that feed on insects are also found in different landscapes and ecosystems found in this area. However, this area has been undergoing land use changes including expanding agricultural activities in recent years (Chu and Phiri, 2015). The Kaindu community is culturally and ethnically diverse, however the dominant indigenous ethnic group is of the Kaonde speaking people. Entomophagy is widely practiced in this community as in many other rural communities in Zambia (Stull *et al.*, 2018).

Despite this background, it is not known how cultural and ethnic diversity, economic transformation or modernity and ecosystem disturbances are affecting entomophagy in rural Zambia. Therefore, this location is suitable for this study because it presents all necessary elements to gain good insights into the practice of entomophagy and the role of edible insects in food security and livelihoods. The following sections give detailed information of different biophysical aspects and human activities in the study area.

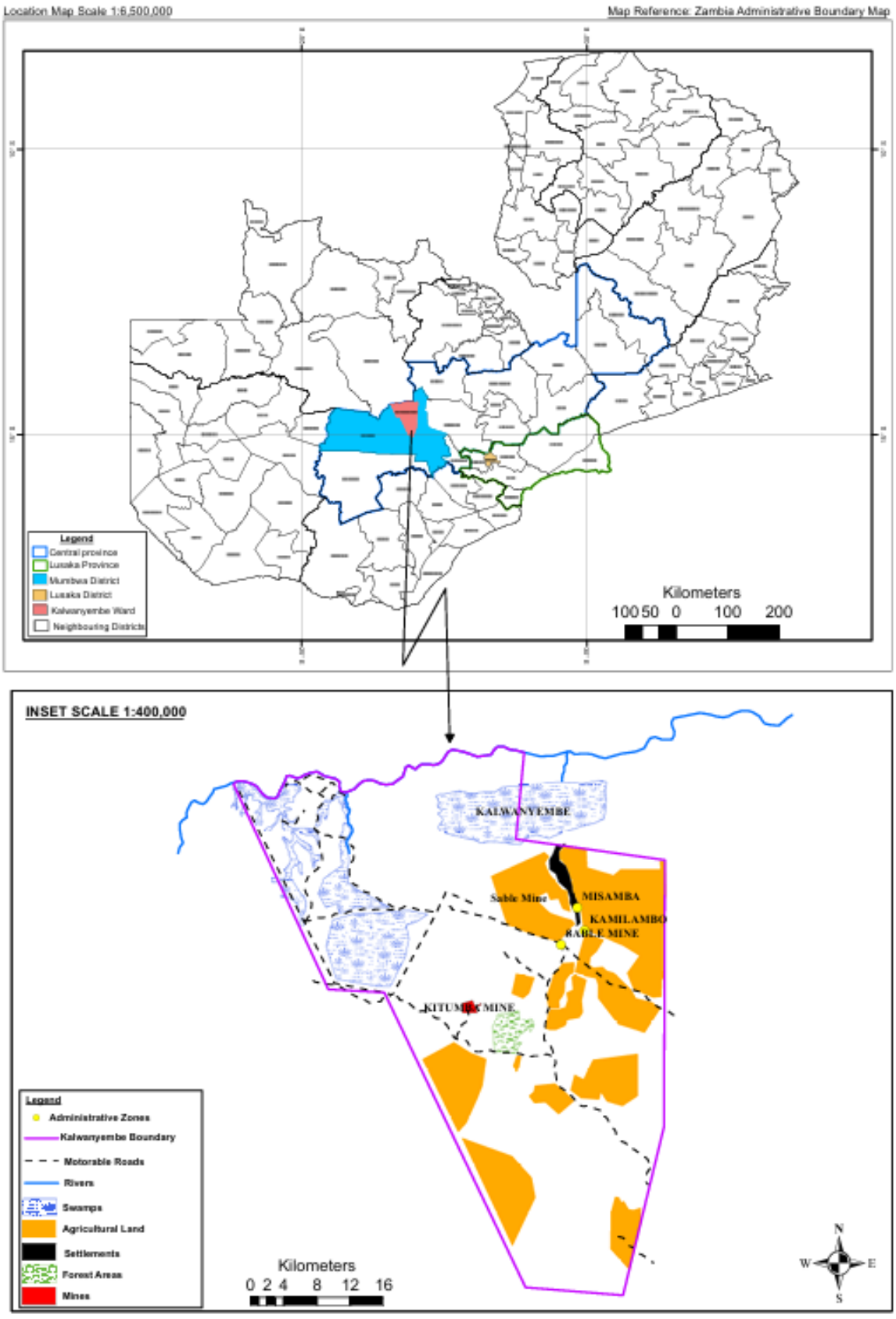

Figure 2. Location of Mumbwa district and study site in the context of Zambia.

3.2 Geology, topography and soils

Kaindu has an altitude range of 1000–1400 m above sea level (asl). Its geology is composed of the Muva Supergroup comprising quartzite, schist, phyllite and conglomerate (DNPW, 2013c). Fluvial-glacial beds, carbonaceous shale, dolomite and ironstones are also common. The relief of this area is mostly flat, however there is a mountain known as Kalenda which has an elevation of 1514 m asl, the highest point in the region. The southern part of Kaindu has red leached plateau soils, small areas of pale grey clays and extensive sands. The other parts of the area have brown to yellowish-brown, friable, clayey to fine loam soils that are well to poorly drained (DNPW, 2013c). The deep dark clays found in the Kafue basin and the river banks hold large amounts of water under wet conditions.

3.3 Climate

Kaindu has a subtropical climate and lies within agro-ecological zone II which receives about 800 to 1000 mm of rainfall annually. The area has two main seasons (wet and dry). The wet or rainy season starts in November to April when temperatures reach a high of 33.9°C. The months of December and January receive rainfall of between 201 and 237 mm respectively (Chisanga *et al*., 2023). The Inter-Tropical Convergence Zone (ITCZ) influences rainfall in the area and results in a growing period of 120–160 days annually, which supports cultivation of a variety of crops. The dry season is divided into the cold season (May–August) and the hot season (September–October). During the cold season, atmospheric temperatures range between 10.8 to 28.4°C and in the hot season temperature reaches an average of 32.4°C while humidity increases to 55% (Zambia Meteorological Department, 2024). However, data from the Zambia Meteorological Department for the period 2000–2019 for Mumbwa district where Kaindu is located shows a decrease in total annual rainfall over the last two decades (Figure 3). The period 2010–2019 recorded less rainfall compared to 2000–2009. However, 2017 rainy season recorded the highest amount of rain in the period (2000–2019) under review (Figure 3). In terms of temperatures, there was a slight increase in maximum annual temperatures for the period 2000–2019 (Figure 4). This means that Mumbwa district has experienced less rainfall and higher temperatures in the last decade. The Kafue River is the main water body in the area but there are also other perennial rivers such as Kalwanyembe, Mushingashi, Nalusanga, and Kankombwe (DNPW, 2013c).

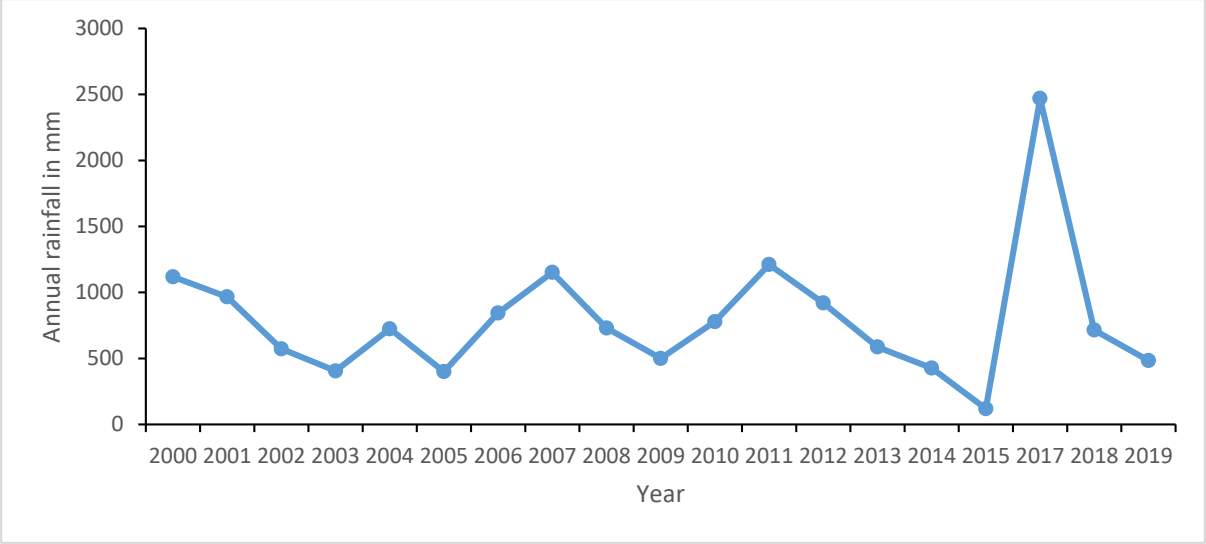

Figure 3. Total annual rainfall in the study area for the period 2000–2019. Source: Zambia Meteorological Department.

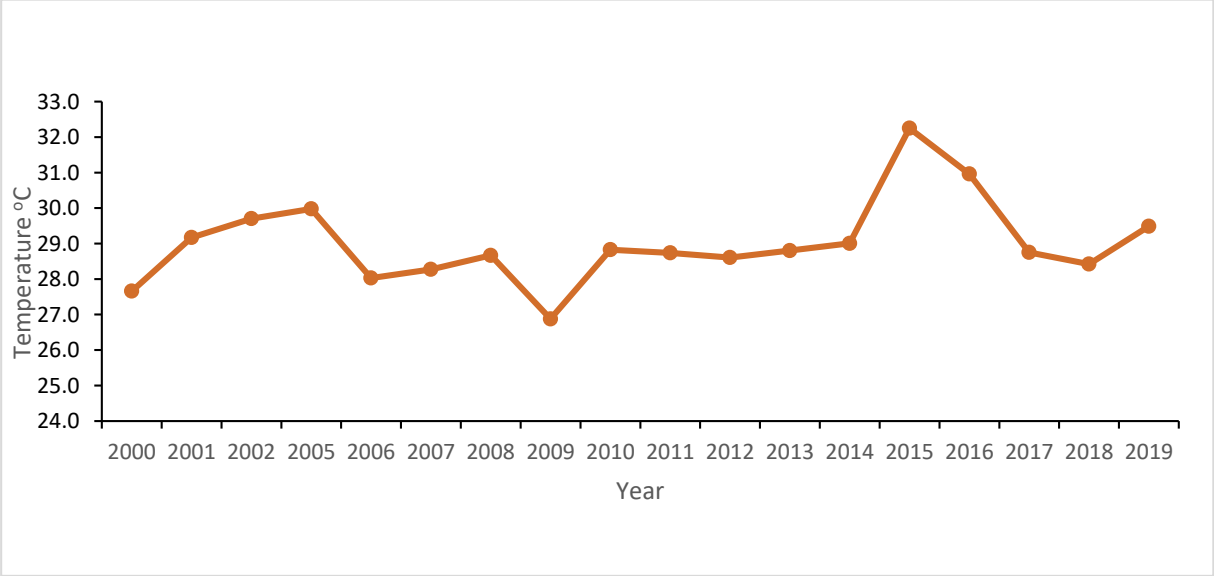

Figure 4. Annual maximum temperatures in the study area for the period 2009–2019. Source: Zambia Meteorological Department.

3.4 Ecosystems

Vegetation cover in the northern and southern parts of the district is that of miombo, *Acacia*, and munga (savanna) woodlands while grasslands which extends up to the Kafue flats cover the western and eastern parts of the district. Kaindu is predominantly characterised by dry miombo woodlands with the presence of *Brachystegia*, *Julbernadia* and *Isoberlinia* tree species with a tree canopy 10–20 m high, representing a transition between Africa's rainforest and semi-arid savanna biomes (Chidumayo, 2019). Termiteria woodland characterised by

Acacia nigrescens is common with an undulating landscape and terrain sloping gently towards the Kafue plain and Kafue River (Forestry Department, 2016).

The Kafue flats wetlands, which is a Ramsar site, passes through some parts of the area. There are also patches of wetlands such as dambos, floodplains and riperian forest along large rivers that include Kafue, Nalusanga and Kalwanyembe. Wetlands host some edible insects such as dragonflies, damselflies, beetles and ants which may contribute to livelihoods and nutrition of people who live in this area. Dambos and floodplains are used for animal grazing in the dry season when upland vegetation is dry. They are also used for vegetable growing. Several other ecosystems (Figure 5) exist in Kaindu and these include wildlife ecosystems (Kafue National Park and Mushingashi Conservancy), forest reserves where caterpillars are found, and agricultural land where flying termites, thief ants, grasshoppers and locusts are found.



Figure 5. Examples of different ecosystems found in Kaindu. (a) Photo showing an agriculture ecosystem where women from one household are working in their maize field, (b) dambo that forms part of wetland ecosystems, (c) grassland ecosystems, (d) open miombo woodland that forms part of forest ecosystems, (e) the researcher standing in the Kafue River.

3.5 Human and economic activities

The 2010 census of population and housing, which is the last official census conducted in Zambia at the time this study was being conducted, indicates that Kalwanyembe ward had a total human population of 7773 of which 52% were male and 48% females (CSO, 2010). Out of this total population (7773), 49.9% were aged below 15 years, 47.8% were between 15 and

64 and 2.3% were 65 years and above. A total of 1400 households existed in the area (CSO, 2010). However, in the period 2010-2022, Zambia's rural population grew at an average annual rate of rate 3.4% (Zamstats, 2022). Kalwanyembe ward of Kaindu chiefdom has two secondary schools (Kalenda and Kaindu) and five primary schools (Kaindu, Miyumbe, Kafwikamo, Kalenda and Kitumba). One primary school is located in each of the four administrative centers of the ward while two schools are located at Kaindu. Although education both at primary and secondary levels is compulsory in Zambia, the literacy rate of adults aged 15 and above stands at 87% while total youth literacy is 93% (UNICEF, 2021). Literacy rates among female youth aged 15–24 is 92% and for male youths of the same age it is 94%. For male adults, the literacy rate is 91% while that of female adults is 83% (UNICEF, 2021). The low literacy levels among females compared to males is mostly due to pregnancies and early marriages (World Bank, 2015). Other public facilities that exist in the ward are two health care and a correctional facility.

Kaindu is ethnically diverse as it has people from different tribes across Zambia such as Tongas, Lenjes and Bembas and includes Zimbabwean migrants, however the area is predominantly Kaonde. Ethnic diversity and a fusion of modernity could possibly be changing socioeconomic and cultural perceptions regarding edible insects.

Kaindu is agrarian in nature and home to a commercial farming block commonly referred to as Big Concession which consists of 180 000 hectares of land under private ownership (Chu and Phiri, 2015). Although Big Concession is located in a rural agrarian community where majority of the local people survive through small scale farming, the farm block consists of commercial and medium scale farms such as Bush Velos. This also includes a Zambia Prison Service farm called Kitumba and Simba Milling that are involved in game ranching, cattle ranching and crop farming. The other notable commercial farm in the area is Amatheon Agri, a Germany based agri-business and Food Company with operations in several sub-Saharan countries. Its operations include smallholder out-grower schemes, storage and supply of crops and livestock to domestic and regional markets, in addition to commercial farming (Amatheon-Agri, 2020).

Smallholder farmers who mainly practice subsistence farming of cash crops such as cereals, soya beans, groundnuts, and cotton depend on rainfed agriculture for their livelihood. Smallholder farmers follow traditional agricultural practices characterized by low farming inputs, low output and heavily depend on family labour with few exceptions who use ox-drawn

power. Majority of these small-scale farmers utilize not more than two hectares of their farms which vary in size ranging from five to 20 hectares (Chu and Phiri, 2015).

Although most of the economic activities are based on cultivation and marketing of crops, artisanal copper and gold mining also form part of the economic activities in the area. A concentrator plant to process 300 tons of copper ore per day is being constructed at Kitumba area within Kaindu (Cedars Minerals Limited, 2022). Other sources of income generating activities include employment in the consumptive and non-consumptive tourism industry, supplemented by trade in artisanal fishing, weaving, rearing of indigenous chickens, honey and edible insects such as locusts, flying termites, mopane worms and grasshoppers when they are in season (Kalaba *et al.*, 2013).

Recent government policies to revive underutilized land through the promotion of investments in agriculture sector as means for economic development has resulted in the expansion of agriculture land in the area and the establishment of a cotton ginnery located in Mumbwa town to support the cotton industry. Expansion of agriculture activities could result in habitat destruction and affect insect diversity and availability. Other livelihood activities are bee-keeping, employment in the tourism sector, harvesting of non-timber products and artisanal fishing especially for the inhabitants of the Kafue flats (DNPW, 2013).

The area is connected to the national electricity grid but not all households are connected to electricity except public places and houses for public workers. Some private individuals and commercial farms that have the capacity to bear the cost of having their homes electrified are also connected to the national electricity grid. Mobile network towers for mobile communication and internet are found in the area, and so a good number of people own information and communication gadgets such as mobile phones and computers. Traditional market places exist where people buy food but the majority grow their own food as the area is mainly agrarian. However, vegetables, meat mostly goat and pork are sold including mushrooms and edible insects like caterpillars when in season at the local traditional market located at Kaindu. This study area is suitable for this research as it would give insight on how different categories of people engage or utilize insects as food and means of livelihoods.

Chapter 4: RESEARCH METHODS

This section focuses on the conceptual framework of how local people use ecological and specifically insect resources, and the research methodology, data collection and analysis methods used in this study. This section also provides detailed information on the procedures and ethical considerations the researcher undertook in order to collect data from participants in the study area that addressed the research aim and objectives of the study.

4.1 Conceptual framework

In recent years, challenges such as climate change, biodiversity loss, ecological damage, land degradation, food insecurity and poverty constitute major challenges threatening sustainability of socio-economic, environmental and human wellbeing (Folke *et al.,* 2021; Gonzalez-Redin *et al.,* 2024). Thus, healthy people, communities and environments depend on the quality, quantity and distribution of environmental and ecosystem services, hence the need to properly manage these services. This means that there is need for transformative approaches to human–nature engagements in the wake of increasing global and regional hunger, malnutrition and poverty levels, particularly in rural communities of developing countries where people depend on the exploitation of biodiversity and ecosystem services for livelihoods (Swierk *et al.,* 2014; UN, 2023; Gonzalez-Redin *et al.,* 2024). However, one of the key challenges in the use of ecosystem services in food security systems is the failure to consider the integrated environmental context of food production (Gonzalez-Redin *et al.,* 2024). This is because most existing policy frameworks to food security are based on single strategies developed in the 1950s to 1970s which were not designed to address the current complex environmental issues, population growth, and declining availability of cultivatable land (Faisal and Parveen, 2004; Gonzalez-Redin *et al.,* 2024). In Zambia, although a policy report on sustainable food systems recognizes the interface between food production and environmental resources (OVP, 2021), the focus is on understanding the constraints and opportunities facing small-scale farmers and agricultural enterprises along the food value chain, rather than the wider context of this issue.

While previous studies of food security and sustainability are rooted in single strategy concepts, sustainability in food systems cannot be confined to a single cause but rather it is a combination of diverse, nonlinear, cross-scale and dynamic factors involving the physical environment, people and communities, and governance and policies across local to international scales (Mathias *et al.,* 2020). A useful framework to understanding ecosystem services and food

security is that of socio-ecological systems (SES), initially advanced by Ostrom (1990), that is relevant for managing complex systems in which humans interact with nature (e.g. Berkes *et al.*, 2008, Folke *et al.*, 2021; Gonzalez-Redin *et al.*, 2024). SES is defined as an interaction of complex and adaptive system of biogeophysical units which are associated with one or more social systems delimited by stakeholders and institutions (Ostrom, 2009). This concept emphasizes that humans should be seen as a part of, and not separate from, nature, and the interactions between them should be treated as a single coupled system that is complex, dynamic, adaptive, interactive and multi-scalar (Delgado-Serano *et al.*, 2015; Norström *et al.*, 2022). The aim of the SES approach as used in this study is to analyze social, economic, and ecological systems within the single coupled system of food security and sustainability (Figure 6). For example, since the majority of rural communities in sub-Saharan Africa have strong ties to their local environment and rely on the extraction of ecosystem services for their livelihoods, it means that decisions made by ecosystem service users may have reciprocal impacts on the ecological systems concerned, including their capacity to provide these services (Gonzalez-Redin *et al.*, 2024). Therefore, the SES approach as used in this study provides a framework for analyzing the linkages between biophysical and social factors that are of relevance to edible insect utilization.

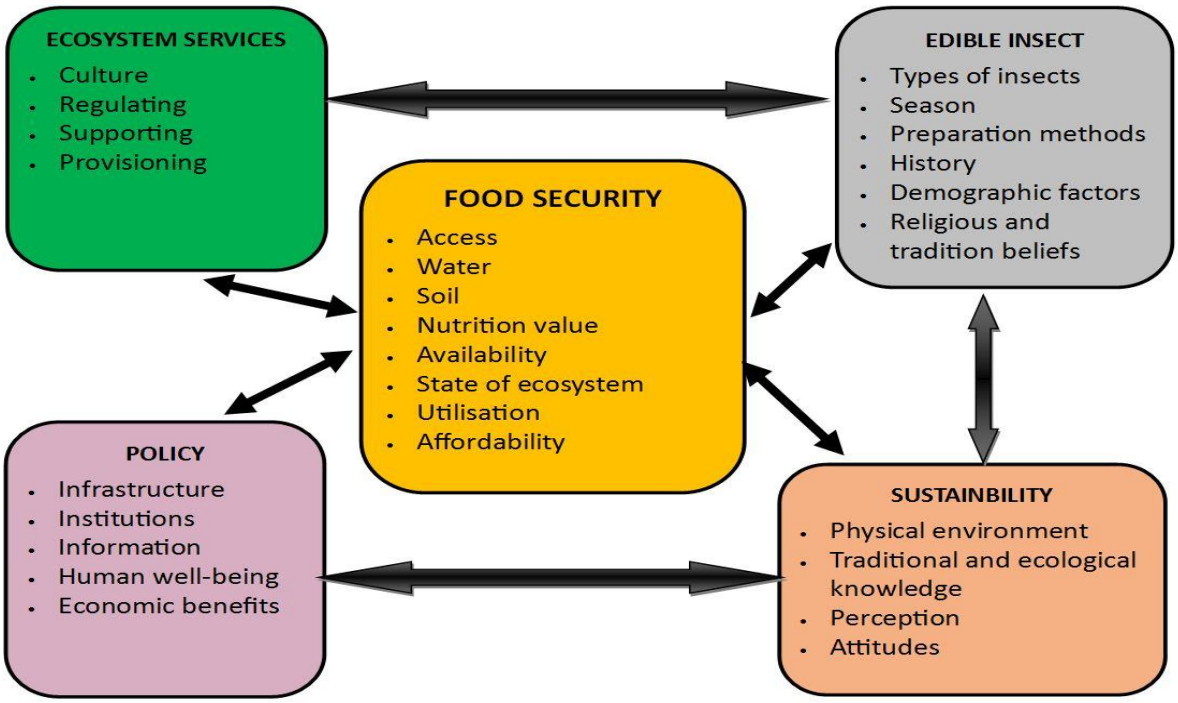

Figure 6. Model illustrating the concept of socio-ecological systems as applied to food security in this study.

Fundamental to the principle of SES is identifying the relevant actors involved in environmental resource management, which aspects of ecosystems should be considered, and how the economic, socio-cultural and environmental aspects of SES are conceived (Everard, 2020). This study explores these questions in the context of the role of edible insects in food security and livelihoods in Mumbwa district, Zambia. Owing to the fact that the study area of the Kaindu chiefdom is surrounded by several ecological regions (including forests, water bodies, agriculture and grasslands), this study investigates how the local community interacts with and benefits from insect ecosystem services and how such services are valued.

A sustainable food system has interlinked components centered on how individuals, groups, or institutions use the environmental and ecological resources available in order to achieve economic, social and environmental protection, without compromising the food security and ecosystem services of future generations (HLPE, 2017). This means that anthropogenic activities should not compromise or threaten ecosystems and habitats that support biodiversity that are critical to sustainable food production and food security. Therefore, a systematic and integrated approach is needed to address both short- and long-term food security and nutrition goals based on edible insects while mitigating negative environmental and social impacts.

The concept of food sustainability is used in this study to understand and connect different ways in which households use edible insects to improve food security and sustain their livelihoods. The use of the SES concept (Figure 7) enables the integration of data from various sources, thus providing a theoretically-grounded means of understanding the dynamics and implications of SES interactions. The concept further allows the examination of complex environmental, ecological and social processes and helps assess the specific context of direct and indirect ecosystem services provided by insects of relevance to local communities. However, as with all concepts, SES comes with its own weaknesses and biases. The concept has been criticized for being overly broad because of its multi-dimensional engagement with many different issues. As such, it reduces the ability of researchers and decision-makers to adequately understand or manage sustainability strategies for ecosystem resources (Fabinyi *et al.,* 2014; Mathias *et al.,* 2020). Additionally, because the concept is widely used across many different disciplines, definitions for some terms such as sustainability, resilience, and adaptation may vary from one discipline to another (Pérez-Soba and Dwyer, 2016).

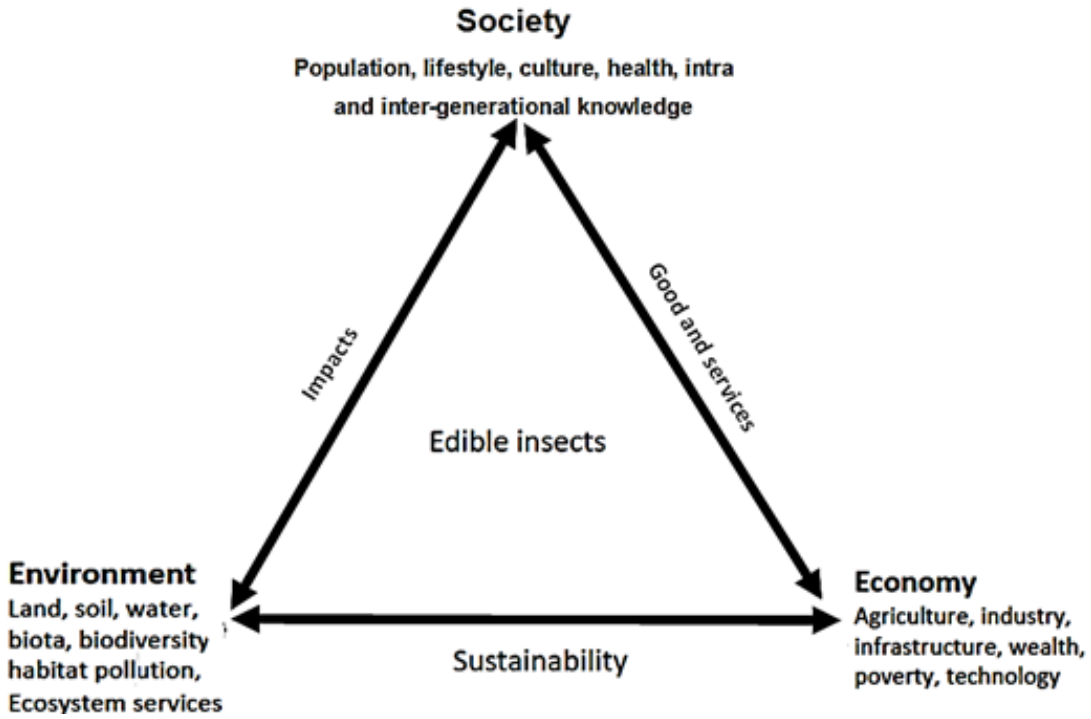

Figure 7. Model for SES that illustrates the interconnections between environmental resources, society and resource utilization. Note that edible insects are a subset of broader environmental resources. Source: Raskin *et al.* (1997).

4.2 Research methodology

An appropriate methodology can guide researchers to adopt the most appropriate approach to collect and analyze data in order to answer the research aims and objectives. Since this study examines the interconnections between insect consumption, cultural values, ecosystem services, food security and sustainability, it adopted a mixed methods approach to collect and analyze data. This approach allows for in-depth investigations of individuals, groups or communities using a variety of data sources and data collection tools such as observations, interviews and questionnaires (Creswell, 2003). A case study approach enabled the researcher to investigate the research topic in an integrated and grounded way.

Quantitative data collected through the use of questionnaires was used to show relationships between independent (age, gender, income, education, religion and culture) and dependent variables (extent of consumption of edible insects) presented in the results section (Chapter 5). Qualitative data which was collected through the use of focus group discussions, a key informant interview and ethnographic observations was used to show the linkages between

factors that influence insect utilization. Questionnaires were used to answer objectives 1, 2, 3 and 4 (Section 1.4). Focus group discussions and ethnographic observations undertaken to address objectives 1, 2 and 3. Ethnographic observations of insect harvesters was done in the month of December when edible insects such caterpillars, flying termites and thief ants were available. One key informant interview was undertaken to answer objectives 2 and 3. Focus group discussions were used to answer objectives 1, 2 and 3. A total of 29 people who included 19 males and 10 females participated in six separate focus group discussions. The focus group discussions involved 11 adult males aged 25 years and above and 8 male youths aged 18–24 years who participated in four separate groups. The two groups of female discussants involved five female youths aged 18–24 years and five adult females aged 25 years and above. On average, each group of discussants constituted around five participants to ensure efficiency and optimum elucidation of data (e.g. Hennink *et al.*, 2019). Separate focus group discussions between older and younger members of the community helped to navigate through some cultural challenges, and provided a conducive environment for the participants to express themselves freely.

4.3 Target population, sample size and sampling techniques

There is a total of 1400 households in Kalwanyembe ward (CSO, 2010). This study targeted 10% of these households as its sample size, therefore a total of 140 questionnaires were administered to 140 heads of households who were made up of 103 males and 36 females. The number of households in this study area was sourced from the Census of Population and Housing undertaken in 2010 (CSO, 2010), because this was the most recent census of population done at the time of data collection. Since the census data did not show the number of total households in each of the four administrative zones for Kalwanyembe ward (namely Kaindu, Kafwikamo, Kamilambo and Misamba), the total sample size of 140 was divided by 4, giving 35 as the number of households to be sampled in each zone. This was done to ensure that the sample size of each zone was broadly proportionate and representative of the study area notwithstanding any changes in population from 2010. The following formula was used to determine the interval ratio at which households were selected for participation:

$$J = \frac{K}{I} = Q$$

where J is the sample size for the study area, K is the population size, I is the sample size for each zone, and Q is interval ratio. Therefore, $1400 = \frac{140}{35} = 4$ as the interval ratio.

Using the above calculation, it was determined that every 4th household in each of the four study sites be considered in the study sample. The groups sampled in each zone comprised of heads of households (either male or female) and adults aged 18 years and above.

4.4 Primary data collection

4.4.1 *Questionnaires*

Primary data using questionnaires (Appendix 1) were collected over a period of 5 months from August to December 2022. In the study area, the rainy season starts from October, reaches its peak in February and normally ends in March. Although a total of 140 questionnaires were administered, only 139 were analyzed because one questionnaire got damaged. Prior steps in obtaining research ethics and procedures for obtaining informed consent from all participants is described below. The questionnaires had a total of 55 questions which required respondents to tick in the appropriate box or provide written explanations to their answers. It was divided in five sections of which section one had 14 questions which looked at household socioeconomic and demographic data, second section had nine questions and looked at household food security, while section three had 10 questions which investigated insect consumption patterns. Section four of the questionnaire had 13 questions which investigated insect collection and preparation methods, while section five had nine questions which investigated edible insect utilization and factors that affected sustainable utilization of edible insects in rural communities. On average, respondents took about 50 minutes to answer the questionnaire.

Respondents were not asked to indicate their ethnic group (tribe) because issues of ethnicity were a sensitive matter in Zambia at the time of data collection, however, the questionnaire gathered quantitative data on the contribution of edible insects to household food security, livelihoods, and to draw statistical comparisons on how different members of the same community perceive edible insects. In terms of the quantities of insects consumed per meal (question 28), respondents were asked to indicate the quantity by using a hand as a method of measurement, due to high illiteracy levels. However, the researcher later bought dried caterpillars *(Gonimbrasia belina)* from the market as they are the ones that were readily available and measured a handful which he weighed on a digital scale (Casa). Completed questionnaires were collected immediately after the respondent finished answering the questions which were written in English or orally interpreted to the local language (Kaonde or Nyanja) by the research assistant to those who did not speak English. Prior to commencing the

activity, questionnaires were pilot-tested to identify areas that needed to be adjusted to ensure that respondents understood what was required of them. Taking into account the COVID 19 situation in the country at the time questionnaires were being administered, they were not physically handled by the respondents but were read out to them while the researcher ticked in the appropriate boxes or wrote down the answers while observing social distancing rules. This approach also helped respondents who had low literacy. The researcher and his assistant ensured that they used hand sanitizers and face mask as they moved from one place to another.

4.4.2 *Focus group discussions*

Focus group discussions were conducted between August and October 2022 and with permission at the venue of Kaindu primary school in Kaindu. The purpose of the focus groups was to develop a comprehensive understanding of the significance of edible insects to the community, how people in the community utilize edible insects, challenges and opportunities that community members experience in insect utilization, and what factors influence the consumption or non-consumption of insects. Each discussion session lasted for an average of one hour and participants discussed 10 questions moderated by the researcher (Appendix 2).

A total of six focus group discussions were conducted to ensure that data collection using this method was extensive and exhaustive from the Kaindu community. All the discussions were held at the venue of Kaindu primary school. Participants in the focus group discussions were recruited from within the Kaindu community because people from the other three communities had travel difficulties. The focus groups were also split in single sex, different age categories, and different education backgrounds so as to maintain gender sensitivity, and to cultivate trust and freedom of expression amongst peers. A total of 29 participants who included nine youths aged 18–24 years and 16 adults over 25 years were recruited. An announcement for voluntary participation in the discussion was done by the research assistant at the local health center, market and the secondary school. Each group had an average of five participants, except for one male adult group which had four participants making a total of 29 (n=6×5=30-1). Focus group discussions allowed for in-depth interactive discussion by different members of the community and this supplemented the data collected through questionnaires. Owing to the COVID 19 situation at the time that the focus groups were held, they were conducted in open air spaces outside the classrooms at Kaindu primary school while observing social distancing. The researcher gave disposable face masks to participants. Hand sanitization was also done before and after the discussion.

4.4.3 *Ethnographic observations*

Direct observations of people collecting different types of edible insects was done by the researcher in Mukubwe area of Chief Mukubwe in Ngabwe district about 80 km northeast of Kaindu chiefdom in Mumbwa district and Kaindu community. This area was chosen to observe the caterpillar collection process because this is where popular species of caterpillars such as *Gonimbrasia belina* (mopane worm) and *Gynanisa maja* (speckled emperor or chipumi) caterpillars were found and collected in bulk. In this activity, the researcher observed the physical environment and habitats of various edible insects, the relationships between the physical environment and the availability of insects, measured the lengths of various types of caterpillars using a flexible plastic ruler, the collection processes used by the participants, and how people of different ages and genders engaged with different types of edible insects, and their preparation methods. An observation schedule (Appendix 3) was prepared before commencement of field observation but this kept on changing depending on the edible insects that were present and the direction of informal discussion undertaken by the participant and the researcher during the observations. This was an invaluable way of understanding the cultural context of insect harvesting and the stories told by participants about their memories, experiences and traditions of insects and environments.

Participants who were observed in this process were different from those that answered questionnaires and participated in the focus group discussions. This was deliberate so as to not influence the participants in their activities. Access to different collection sites was sought through community leaders with the help of the local research assistant to help navigate the local terrain. At the collection site for caterpillars in Ngabwe, one group of collectors was observed. Although several other groups existed in the area, they had similar gender, age categories and camping conditions, therefore one group was considered representative of the others. The observation was done over a period of two days.

Participants within the Kaindu community were directly observed in the collection of flying termites, grasshoppers and thief ants. The researcher did not get involved in this collection process. The participants for the observations comprised five males and four females. In the process of observation, the researcher observed the sites where edible insects were collected from, and listened to and engaged in informal and unrecorded but noted conversations with the

collectors and consumers of insects. This was done both in the field and in the participants' homes, and with the view of examining the methods used to control and harvest edible insects as well as to develop an understanding of insect consumption patterns and storage methods (Table 2).

Table 2. Examples of what was observed during field observations.

What was observed	Insect types and collection methods, where and when they are collected
Preparation methods	How edible insects are prepared, how insects are consumed, who prepares insects for consumption, and how insects are preserved
Informal questions asked	Why the participants use insects, why specific type of insects, why prepare edible insects in the ways they do, and what socioeconomic and cultural values they attach to edible insects

These observations helped the researcher evaluate insect harvesting in their natural context and settings, and how human activities affected edible insect availability and preferences among different members of the community. Direct observations further enabled the researcher to investigate perceptions, attitudes and knowledge gaps among different community members. The observations were done in the month of December 2022. With consent, the researcher took photographs and field notes on how people interacted with edible insects and the environment. These observations were organized, analyzed, and integrated with results from interviews and focus group discussions and are presented in Chapter 5.

Owing to the fact that the study was conducted during the period when COVID 19 was still active, the researcher gave disposable face masks to participants and hand sanitization was done before and after observations. Open air spaces were always preferred while observing social distancing. The researcher stayed with the locals for a period of one week in their village and informally observed the local entomophagy.

4.4.4 *Key informative interview*

One interview was held with the area councilor for Kalwanyembe ward, at his residence. This lasted for one hour. The semi-structured interview guide (Appendix 4) had 10 questions which mainly investigated the cultural beliefs and practices in the community as well as past and present trends in the utilization of edible insects. The councilor was purposively selected because he sits in the chief's traditional decision-making council. The councilor had lived in

the community for over 40 years and was familiar with local cultural and traditional practices including indigenous and ecological knowledge of various types of edible insects. He was able to communicate effectively because he was able to speak English and other dialects like Nyanja and Bemba which the researcher was conversant with. The interview was recorded with verbal consent from the participant using an audio recorder on a cellphone.

4.5 Data analysis

Quantitative data from questionnaires were coded and entered into Microsoft Excel (v 2020) to record the frequencies and percentages regarding dependent (consumption of edible insects) and independent variables (age, gender, education level, income status, religious and traditional beliefs and environmental factors) in order to draw linkages and relationships, identify patterns, and the extent of insect consumption in the community. In order to accurately record and organize data in a structured manner, a data table was created in Excel. The data table had three columns for entering data categories. The first column was for entering all possible answers from the questionnaire, the second column was used to record tallies for each data category while the third column was used to record the frequencies or totals in terms of percentages for each tally counted in each data category. The results are presented in the form of graphs, charts and tables in Chapter 5.

Qualitative data from focus group discussions and interviews were recorded on an audio recorder with consent from the respondents and later transcribed to text, coded and grouped in thematic areas in order to come up with meanings and relationships. Each focus group discussion was numbered and discussants given participant codes sequentially from 1 in focus group 1 to 29 in focus group 6. The transcriptions were put on a folder in Microsoft Word and were read over and compared with the audio to ensure accuracy (Braun and Clarke, 2008). Relevant phrases or sentences in the text were given codes and highlighted in different colors to correspond with the codes. The coded text was collated and placed into groups in order to generate themes. Themes are topics that come up frequently among respondents (Neuman, 2014). The grouped themes were reviewed by combining, splitting and discarding some thematic areas to ensure that the themes retained were useful and an accurate representation of the data (Braun and Clarke, 2008). The analysis of themes was complemented by photos, direct quotations and notes from direct observations. Additionally, the researcher reviewed annual reports and publications from institutions such as FAO that had previously conducted research

on edible insects in Africa, in order to complement primary data in answering the study objectives.

4.6 Ethical considerations

This study was ethically reviewed and approved by the University's Human Research Ethics Committee (Non-Medical) which issued ethics certificate number H22/01/22 (Appendix 5). Ethics clearance followed a vigorous application process which required that all processes for recruitment of research participants be accurately described and information sheets and consent forms for the different data collection instrument be supplied (Appendices 6–9). This also included draft versions of the questionnaire, focus group activities, interview schedule and ethnographic observation guide.

Prior to the commencement of data collection, a letter requesting permission to conduct research in the Kalwanyembe ward of Kaindu chiefdom was written to the area councilor (Appendix 10) and written permission (Appendix 11) was later granted. Verbal permission was also granted by the Secretary Palace for the traditional authority.

Participation in this study was voluntary and all participants provided verbal informed consent to participate and also to audio-record all activities. For analysis and reporting, all data were anonymized, considered as confidential, and stored securely. Data collection was done with the help of a local research assistant who was recruited to help with administration of questionnaires, verbal interpretation of the questions in the local languages whenever necessary, and navigation of different landscapes for ethnographic transact walks. Appropriate edible insect identification terminologies were used using common local languages (Kaonde, Nyanja and Bemba) so as not to confuse respondents. Where necessary, photos of edible insects were shown to participants to elicit comments.

Chapter 5: RESULTS

5.1 Introduction

This chapter presents the data collected from August to December 2022 in the study area to address the objectives and key questions that the study sought to answer (discussed in Chapter 1). The findings are presented in form of graphs, charts, tables, photographs and direct quotes from participants who were anonymized (discussed in Chapter 4). Data collected through different instruments (described in Chapter 4) was integrated to analyze and understand the degree of acceptability of edible insects and the extent to which they contributed to household food security and livelihoods of the people in Kaindu chiefdom.

The order of data presentation followed the structure of the questionnaire where socio-demographic data are presented first, followed by data on household food security and livelihoods. Both are presented textually and in the form of graphs and tables. Findings on human–ecosystems interactions, edible insect utilization, and sustainability challenges obtained through direct observations, focus group discussions and the key informant interview are presented in form of direct quotes, thematic analysis, and photographs where applicable.

5.2 The socio-demographic characteristics of respondents

5.2.1 *Age distribution of respondents*

Out of 139 questionnaires administered to heads of household, the majority (31%) respondents were aged 40–49 years. Thus, most participants were middle aged (40–49 years) (Figure 8).

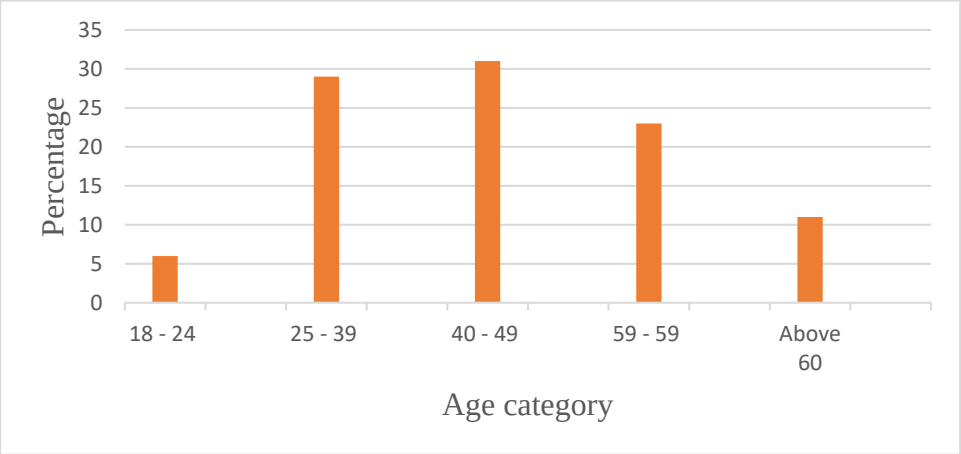

Figure 8. Age distribution of respondents in the study area.

Out of 139 heads of household that answered the questionnaire, the majority (71%) of respondents were male headed households. Out of the 99 male households, 8% respondents were aged 18–24, 25% were 25–39 years, 35% were 40–49 years, 22% were 50–59 years, and 9% were above 60 years. The modal class of male households was therefore 40–49 years. Out of 139 heads of household that answered the questionnaire 29% were female headed households. Out of 40 female households, 3% respondent were aged 18–24 years, 7% were 25–39 years, 12% were 40–49 years, 32% were 50–59 years, and 35% were above 60 years. This shows that female household heads were generally older than male ones.

5.2.1.1 Household sizes and composition

Out of 139 questionnaires administered to heads of household, 49 of households comprised of seven people per household while 8 had 16 people per household (Figure 9). Out of the eight households that comprised of 16 people per household, 5 respondents were aged 50–59 years while one only was aged 40–49 years (Figure 9). This was indicative of multigenerational households.

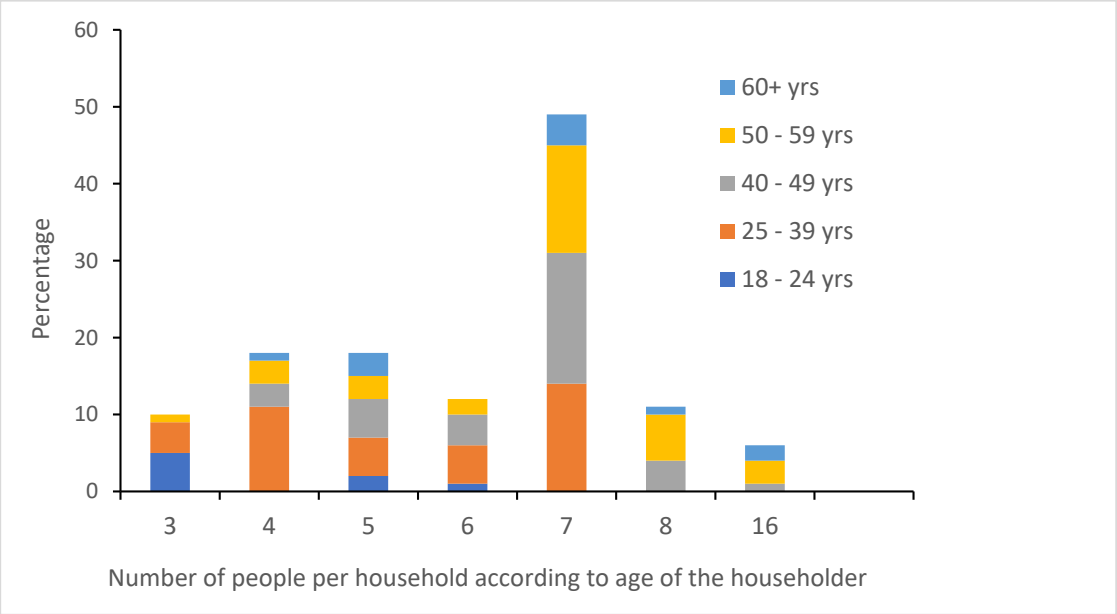

Figure 9. Household size in relation to age of head of household.

Out of the 10 households comprising of three members, 9 households were headed by males and 1 by a female. Out of the 18 households that had four members, 14 households were headed by males and 4 by females. Out of the 18 households that had five members, 12 households were headed by males and 6 by females. Out of the 12 households that had six members, 9

households were headed by males and 3 by females. Out of the 47 households that had seven members, 33 households were headed by males and 14 by females. Out of the six households that had 16 members, 5 households were headed by males and 1 by female. This shows male headed households overall had bigger family sizes than households headed by females.

5.2.1.2 Education levels of the household heads

Out of 139 questionnaires administered to household heads, 9% did not have any formal education, 51% had primary education, 25% secondary education, and 15% tertiary education. Most household heads who did not have any formal education were aged 40–49 years, whereas those with primary education only fall into a range of age brackets (modal class 40–49 years), and those with secondary or tertiary education were mainly 25–39 years. In terms of gender, out of 12 heads of household that did not have formal education, 42% were males and 58% females. Out of 71 heads of household that had primary education, 80% respondents were males while 20% females. Out of 35 heads of household that had secondary education, 69% respondents were males and 31% females. Out of 21 heads of household that had tertiary education, 62% respondents were males and 38% females. This shows that overall males had a higher education level than females. Out of 129 households that had children that attended school primary and secondary school, majority (58%) children did not complete secondary education, therefore, literacy levels in this community were likely to be low.

5.2.1.3 Sources of livelihood

Out of 139 questionnaires administered to heads of household, half (50%) of the respondents depended on agriculture and (10%) on formal employment (Table 3). In this community, male headed households dominated the agriculture and fishing sector while female headed households dominated in edible insects and formal employment (Table 3). Out of 70 heads of households that depended on agriculture, half (50%) of all respondents used agriculture as a source of income alone, 33% respondents used agriculture as a source for both income and food security, and 17% for food security alone. Out of the 70 heads of household involved in agriculture, the majority (76%) grew maize and soya beans, 20% maize, groundnuts, sunflower and cotton, and 4% maize only. This shows that there was a general lack of crop diversification as the majority of households (76%) grew only two subsistence crops.

Table 3. Sources of livelihoods in relation to gender.

Main source of livelihood	Male		Female		
	Frequency	%	Frequency	%	Total
Agriculture	58	83	12	17	100%
Fishing	18	95	1	5	100%
Insect collection	17	47	19	53	100%
Formal employment	6	43	8	57	100%
Total	99		40		139

Of the four traditional domain (agriculture, fishing, edible insects, formal employment) of livelihoods for people of various age categories in this community, agriculture sector was dominated by middle aged people (40–49 years), fishing and edible insects by the middle aged and older people (40 years and above) while formal employment was dominated by young people (25–39 years) (Table 4).

Table 4. Sources of livelihoods in relation to age.

Age category	Agriculture		Fishing		Edible insects/ insect products		Formal employment	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
18-24	4	6	0	0	4	11	0	0
25-39	19	27	4	21	8	22	9	64
40-49	21	30	5	26	12	33	5	36
50-59	15	21	5	26	12	33	0	0
60 and above	11	16	5	26	0	0	0	0
Total	70	100	19	100	36	100	14	100

5.2.1.4 Households income levels in relation to gender

In terms of annual income ranges, out of 139 questionnaires administered to heads of household, 39% of households earned Kwacha K987–K5000 (about $37–$188) while those that earned above K20 000 (about $754) were the minority (13%) (Table 5). In terms of the relationship between gender and income levels, overall males dominated among respondents that earned up to K5000 and those that earned above K20 000 annually while females dominated among respondents that earned K20 000 annually (Table 5).

Table 5. Household income levels in relation to gender.

Annual income range	Male		Female		
	Frequency	%	Frequency	%	Total
K987–K5000	43	80	11	20	100%

K5000–K10 000	30	71	12	29	100%
K10 000–K20 000	8	35	15	65	100%
K20 000 and above	18	90	2	10	100%
Total	**99**		**40**		**139**

Out of 70 heads of household that depended on agriculture, 43% of respondents earned K987–K5000 (about $37–$188), 29% respondents earned K5000–K10 000 (about $188–$377), 14% respondents earned K10 000–K20 000 (about $377-$754), and 14% respondents earned above K20 000 (about $754). Out of 19 households that depend on fishing, 47% of respondents earned K987–K5000 (about $37–$188), 26% of respondents earned K5000–K10 000 (about $188–$377), 21% of respondents earned K10 000–K20 000 (about $377–$754), and 5% above K20 000 (about $754). Out of 36 heads of households that depended on edible insects, 42% of respondents earned K987–K5000 (about $37–$188), 36% K5000–K10 000 (about $188–$377), and 22% K10 000–K20 000 (about $377–$754) while none earned above K20 000. Out of 14 of heads of household that depended on formal employment, the majority (64%) earned above K20 000 (about $754), 7% K10 000–K20 000 (about $377–$754, and 29% K5000–K10 000 (about $188–$377). This shows that the majority of people in formal employment earned higher incomes especially when compared to edible insect harvesting.

5.2.1.5 Alternative sources of income from the main economomic domain

Out of 139 questionnaires administered to heads of household, the majority (74%) of respondents indicated that they kept livestock as a form of alternative source of income while 26% did not. Of those 103 households that kept livestock, 32% kept chickens, 22% chickens and goats, 16% goats, 15% cattle, 9% cattle and goats, and 5% sheep and pigs. This shows that poultry was the most popular alternative source of income for many households in this community. Out of the 36 households that did not keep livestock, 47% mentioned that they did not have capital to keep livestock, 42% indicated that they did not have enough space, and 11% did not state any specific reasons. This indicates that lack of adequate financial resources was the most significant factor that prevented households from keeping livestock. Other than livestock, out of 139 heads of household, the majority (75%) of respondents indicated that they had alternative sources of income away from their traditional domain of income (agriculture, formal employment, fishing and edible insects), 18% respondents did not have and 7% did not state their position. Of the 104 households that were engaged in other forms of income generation, 35% were engaged in informal business, 26% in other types of farming, 14% edible insects, 14% in gardening, and 11% in fishing.

Of the four traditional domain of incomes that existed in this community (agriculture, formal employment, fishing and edible insects), the majority (70%) of respondents that did not have alternative sources of income belonged to households that depended on fishing while the minority (5%) belonged to those households that depended on edible insects (Figure 10).

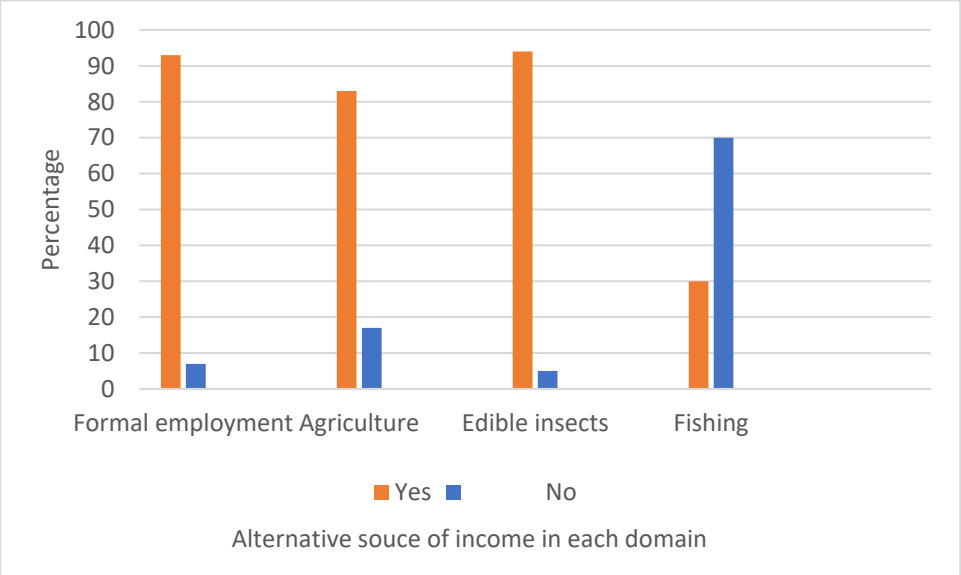

Figure 10. Number of respondents with alternative source of income in each economic domain.

Out of the 58 households that had alternative sources of income among the households that were engaged in agriculture, 66% respondents were engaged in informal businesses, 12% in fishing, 12% in collection of edible insects, and 10% in gardening. Out of the 12 households that did not engage in other income generating activities among the households that were engaged in agriculture, 67% mentioned that they made enough money from agriculture while 33% did not state their reasons. Out of the 19 heads of household that were dependent on fishing, 26% were also engaged in agriculture as alternative source of income, 21% in collection of edible insects, and 53% did not have any alternative sources. This shows that fishing was the most economically precarious activity. Out of the 10 fishers that did not have alternative sources of income, 70% said that this was because they did not have land, and 30% said that they made enough money from fish sales. Out of 14 heads of household who depended on formal employment, 69% were engaged in agriculture as alternative source of income and 31% gardening. Out of 36 heads of household who were dependent on edible insects, 39% respondents were engaged in agriculture as alternative source of income, 28% gardening and 28% informal businesses while the 5% that did not have alternative sources of income

mentioned that they generated enough money through training other farmers in apiculture (bee-keeping). This shows that farming was the most prominent alternative source of income across the other three (formal employment, fishing and edible insects) traditional domains of income generation.

5.2.1.6 Household religious beliefs

Out of 139 questionnaires administered to heads of household, majority (99%) respondents indicated that they followed the Christian faith while 1% followed African traditions. Out of the 137 Christian households, majority (79%) respondents were Catholic, 13% Adventist, and minority (8%) Jehovah's Witness.

5.3 Household food security

5.3.1 Households that experienced food insecurity

In terms of food security, out of the 139 heads of household that answered the questionnaire, the majority (62%) of respondents indicated that they did not manage to have food all year round (and thus are considered food insecure) while 38% households did have access to enough food (and thus are considered food secure) (Figure 11). Out of the 86 food insecure households, 69% of heads of household depended on agriculture, 15% on edible insects, 3% on fishing and only 1% on formal employment. Thus, the majority of food insecure households are those that depended on agriculture.

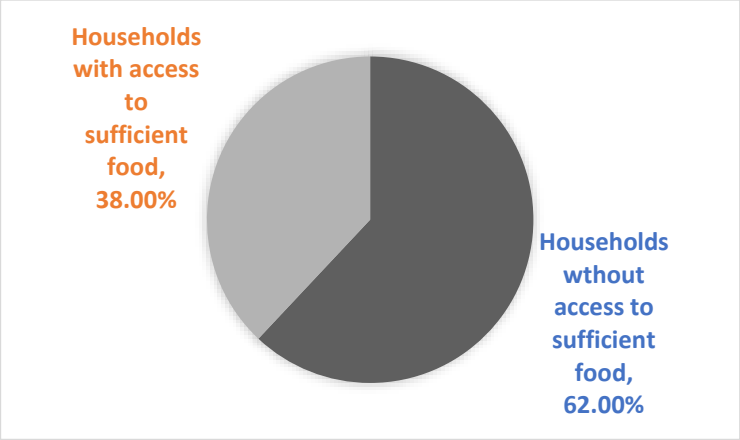

Figure 11. Number of food secure and food insecure households.

Out of 86 heads of household who experienced food insecurity, 94% of households with respondents aged above 60 years did not have access to sufficient food while those aged 18–

24 were those least affected (Figure 12). This shows that households managed by younger and middle aged people (18–49 years) were more food secure than households managed by older people (50 years and above) (Figure 12).

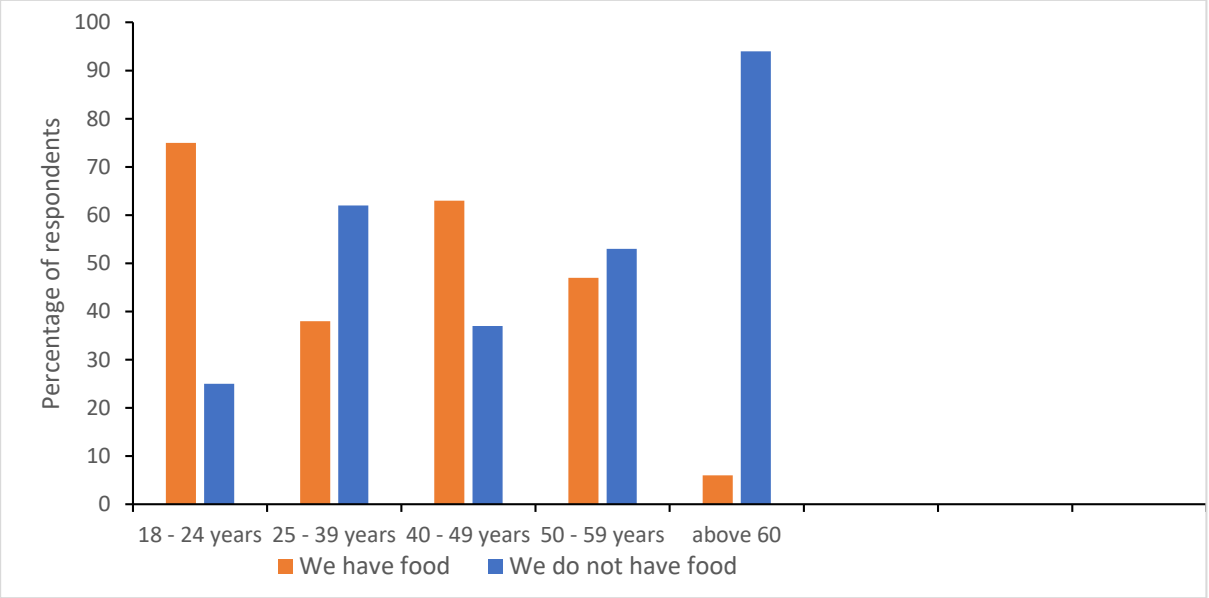

Figure 12. Household food insecurity in relation to age.

Out of 86 households that experienced food insecurity, majority (91%) respondents were male households while 9% were female (Figure 13).

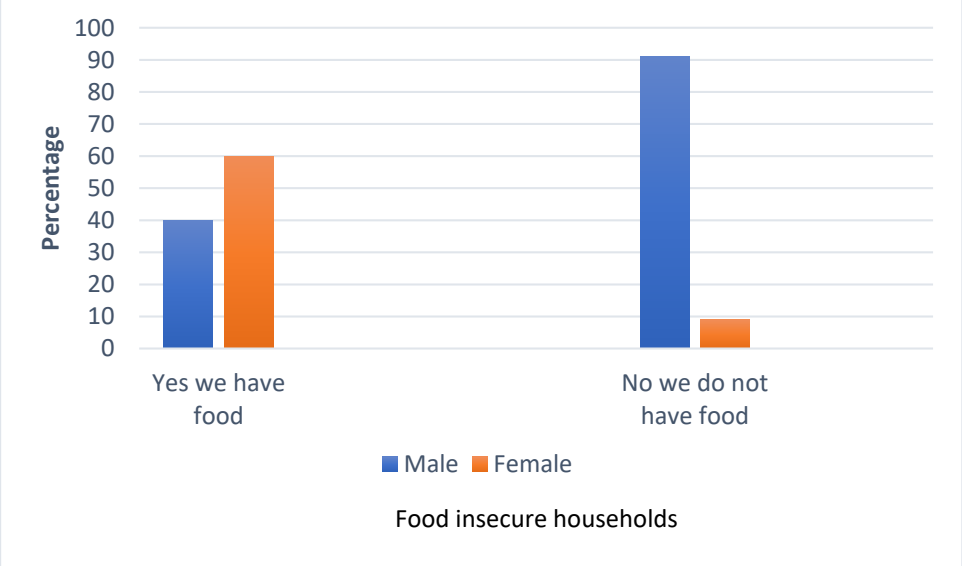

Figure 13. Household food insecurity in relation to gender.

5.3.2 Periods during which households ran out of food

Out of 86 households that did not have access to sufficient food, 92% of households mentioned January to March as the period they ran out of food, 6% households mentioned October to December, and 2% indicated April to June. This shows that the rainy season in the study area (January–March) was the period when the majority households experienced food insecurity.

Out of the 139 questionnaires administered to heads of household, 59% of respondents indicated that children were more affected during periods of food shortages while 27% respondents indicated adults and 14% indicated both children and adults. Out of 139 heads of household that answered the questionnaires, 58% of respondents had two meals per day, 38% three meals per day, and 4% had one meal per day. Out of the 99 male headed households, 67% had two meals per day while out of 40 female headed households, 55% had three meals a day (Table 6)

Table 6. Number of meals consumed per household a day in relation to gender.

Number of meals per day	**1**	**2**	**3**	**Total**
Male	2	66	31	99
Female	3	15	22	40
Total	5	81	53	139

5.3.3 Coping strategies for household food insecurity

Out of the 86 households that did not have access to food all year round, the majority (56%) reduced the number of meals taken per day, 24% depended on doing piece work and similar opportunistic employment in order to increase their income, and 20% conducted informal businesses. All of these can be considered as strategies to enhance household food security. Out of the 53 households that did not experience food shortages, the majority (85%) indicated that they obtained enough food from their farms or gardens, while 15% depended on purchasing extra food. This shows that food storage was the main strategy used by food secure households to enhance food security while meal reduction was the common method used by food insecure households. Out of the 53 households that had access to food, 57% had only one food source while 43% had more than one food source available. Out of the 23 households that had alternative sources of food, 78% engaged in gardening, 13% in wild food collection, and 9% made use of charitable food aid. This shows that gardening was the most significant contributor to household food security.

5.3.4 *Household expenditure*

Out of 139 questionnaires administered to heads of household, 42% of respondents used their income to purchase relish (food snacks), 29% groceries and relish, and 29% mealie meal, cooking oil, relish and groceries. This shows that although a range of commodities was bought by households, relish was the most common. Out of the 58 households that bought one product (relish) only, the majority (78%) were farmers, 12% were insect collectors, 7% fishers, and 3% had formal employment. Out of 41 households that bought two products (groceries and relish), 49% respondents were farmers, 22% insect collectors, 17% formal employment, and 12% fishers. Out of 40 households that bought three products (mealie meal, cooking oil, relish and groceries), 50% were insect collectors, 25% fishing, 13% in formal employment, and 13% farming. This shows that most farming households bought one product (relish), those in employment two products (groceries and relish), and insect collectors/fishers three products (mealie meal, cooking oil, relish and groceries).

Figure 14 shows the amount of money that each household spent on food purchases on a monthly basis. Out of 139 questionnaires administered to heads of household, 35% of respondents spent K105–K400 (about $4–$15) of their income on food purchases and minority (6%) respondents spent above K2000 (about $74) monthly (Figure 14).

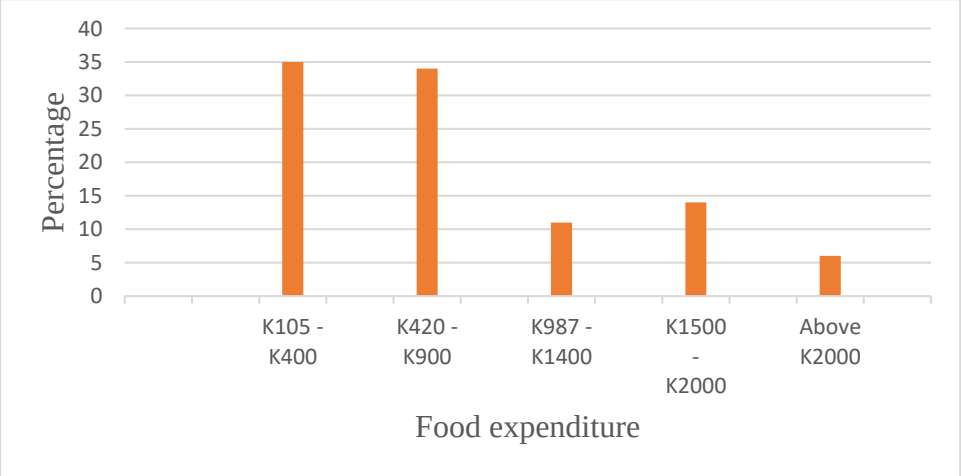

Figure 14. Distribution of household income that is spent on food every month. (Note: $1 was equivalent to K26 at the time of data collection.)

Out of 49 heads of household that spent K105–K400 (about $4–$15), 59% were males and 41% females. Out of 48 households that spent K420–K900 (about $16–$34), 75% were males

and 25% females. Out of 14 respondents that spent K987–K1400 (about $37–$53), 79% were males and 21% females. Out of 19 households that spent K1500–K2000 (about $57–$75) all were males, and out of the nine households that spent above K2000 (above $57), 89% were males and 11% female. This shows that male headed households generally spend more on food purchases than female headed households.

5.3.5 Diets for various households

Out of the 139 questionnaires administered to heads of household, 58% of respondents consumed pap (thick starch porridge made of maize meal) with leafy vegetables on a daily basis, 21% respondents consumed a combination of pap with fish, meat and vegetables, 11% respondents consumed pap and fish only, and 10% respondents consumed pap and meat only. This shows that the majority (58%) households consumed the simplest meals only and without significant proteins. Out of 80 respondents that consumed pap and vegetable only, 30% sourced their vegetables from within a distance of 0–2 km radius from their household, 14% 2–4 km, 38% 4–6 km, and 19% above 6 km. Out of the 30 respondents that consumed pap with fish, meat and vegetables, 17% sourced their food stuffs from 0–2 km radius, 7% 2–4 km, and 63% from above 6 km radius from their households. This shows that vegetables were mostly sourced from 6 km radius while fish and meat were sourced from longer distances of above 6 km radius from households. Out of 139 questionnaires administered to heads of household, 62% respondents produced their own food, 37% of households purchased food from the local market, and 1% of households purchased food from Mumbwa town, located about 80 km south of Kaindu. This shows that majority (62%) households produced their own food.

5.4 Insect consumption

5.4.1 Insect consumption and the rating of insects as food

Out of 139 questionnaires administered to heads of household, 68% of respondents indicated that they consumed edible insects while 32% did not. Out of the 94 heads of household that consumed insects, 55% consumed a combination of *Gonimbrasia belina* and *Gynanisa maja* (caterpillars), while *Ruspolia nitidula* and *Ruspolia differens* (grasshoppers) were the least consumed (by 5% of respondents) (Figure 15). This shows that *Ruspolia nitidula* and *R. differens* grasshoppers were the most undesired insects because they were considered as socially unacceptable.

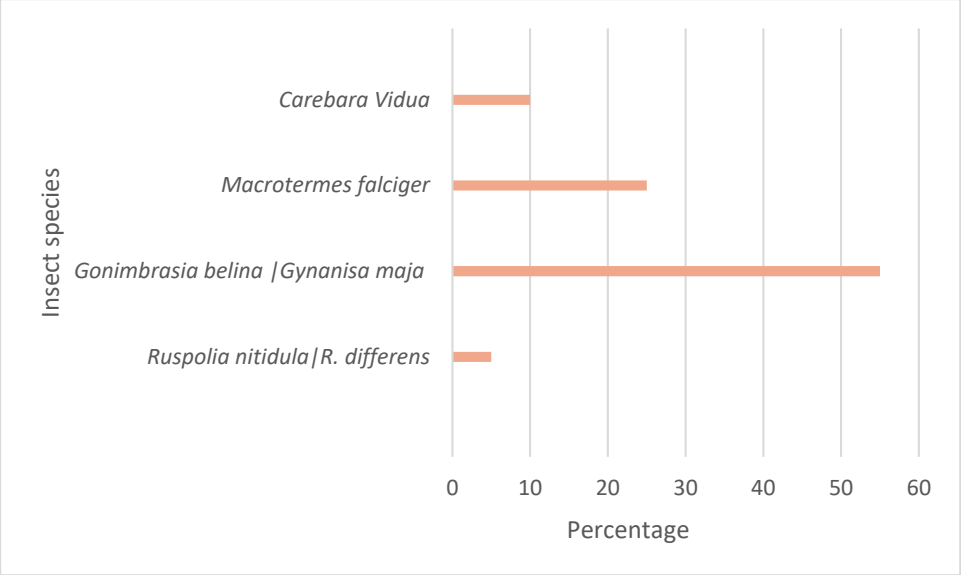

Figure 15. Type of insects consumed by households.

Out of the 24 respondents that consumed *Gonimbrasia belina* and *Gynanisa maja* (caterpillars), 50% were males and 50% were females. Out of 47 respondents who consumed a combination of *Gonimbrasia belina* and *Gynanisa maja* (caterpillars) and *Macrotermes falciger* (termites), 83% were males and 17% females. Out of nine respondents that ate *M. falciger*, 56% were males and four (44%) females. Out of nine respondents that consumed *Carebara vidua* (African thief ants), 67% were males and 33% females. Out of five respondents that ate *Ruspolia nitidula* and *Ruspolia differens* (grasshoppers), 80% were males and 20% female. This shows that females preferred caterpillars to any other type of edible insects while males consumed more of all the available types of edible insects. In terms of age category of respondents in relation to insect consumption, the majority (81%) of older respondents (aged above 60 years) consumed edible insects compared to younger (aged 18–24 years) respondents (Figure 16).

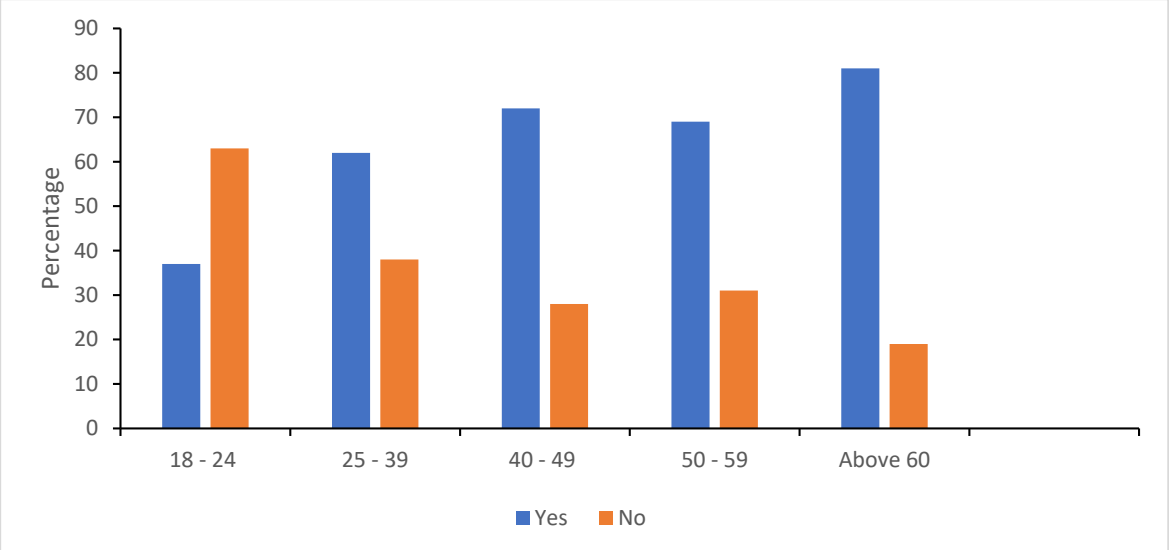

Figure 16. Insect consumers and non-consumers in each age category.

Out of the 45 respondents that did not consume edible insects, 47% cited allergies as the reason for not consuming insects, 35% indicated that they did not consume edible insects because entomophagy was not part of their culture, and 18% mentioned that they found insects to be unpleasant. In terms of rating the importance of edible insects as source of food, out of 139 questionnares administered to heads of household, 44% of respondents rated edible insects as important, 39% as very important, 9% as slightly important and 8% respondents rated insects as a not important source of food.

It was observed by some focus group discussants and the area councilor that in this community, entomophagy was used historically because the community was a hunting community which also survived on the consumption of edible insects amongst other wild foods such as edible wild plants, fruits and vegetables. It was observed by the reseacher that entomophagy formed part of the local food culture due to the need to maintain ancestral practices, leading to wide social acceptability of entomophagy across people of different ages, gender and socioeconomic status. Commenting on this matter, the area Councilor said:

> *"Historically, normally, our forefathers were hunters. So, they used to spend most of their time in the bush. So, I think that's where you find that when they didn't kill animals, they used to resort to feeding on insects. They would select certain insects, not all of them but certain insects."* (Key informant interview, Kalwanyembe ward Councilor)

It was further noted that because edible insects were considered as normal food, their presence or availability brought joy and happiness to the community because insects helped to mitigate hunger and food scarcity especially when fish and game meat were scarce. For example, it was illegal to hunt for game meat or fishing without a license, therefore insects were used to fill the nutritional gap that existed**.** Highlighting the acceptance of edible insects as source of food to this community, 62% of the 29 respondents that participated in focus group discussions mentioned that insects played an important role as food, therefore whenever they were available, people collected them to enhance household food security. For example, adult female discussant number 15 said:

> *"Now it is illegal to hunt for game meat, they arrest, even fish is difficult to find. So, when you find edible insects especially caterpillar, you feel lucky, it feels like its meat that you have found. People in the community become very happy, very happy. We know to say we will have food to eat, we will be fat."* (Female adult, focus group discussion 3)

Adult male discussant number 20 said:

> *"We regard edible insects as relish, nothing else to think of edible insects. Whenever they show up, we know that now we have relish. We don't have negative thoughts or misgivings concerning insects. We become happy when they are available, no two ways about it."* (Male adult, focus group discussion 4)

This shows that the majority (62%) of people in this community held positive attitudes towards edible insects as a food source. It was further observed that the importance or significance of edible insects was increasing due to the fact that they were free resources as they were harvested at no cost to the collectors while on the other hand, it was illegal to hunt for game and fish without licenses which were bought at high costs, hence, making it difficult for the local community to rely on game and fish.

5.4.2 *Factors causing variations in the consumption of edible insects as food*

Out of the 94 households that consumed edible insects, 74% of respondents indicated that they consumed insects because of nutrition, 14% for cultural reasons, 5% because of taste, 3% for medicinal reasons, and 3% because it was their only food. Out of 94 households that consumed insects, 33% ate insects twice a week, 26% occasionally, 21% once a week, and 20% monthly. In terms of the quantities that were consumed per meal, 39% of consumers ate more than a

handful (more than around 92 g) of insects per meal while 19% consumed less than a handful (less than around 92 g) of insects per meal (Table 7). This shows that insects make up a significant part of routine meals. In terms of the motive and the quantity of insects consumed per meal, out of 70 respondents that consumed insects because of nutrition, majority (43%) consumed a handful of insects per meal while the minority (21%) less than a handful (Table 7). This means that insect diets were an important contributor to nutrition.

Table 7. Quantities of insects consumed per meal.

	Less than handful (less than 92 g)		**Handful (92 g)**		**More than a handful (more than 92 g)**	
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**
Nutrition	15	83	30	81	25	69
Culture	3	17	4	11	6	17
Taste	0	0	2	5	3	8.
Medicine	0	0	0	0	0	0
Only food	0	0	1	3	2	6
Total	18	100	37	100	36	100

5.4.2.1 Insect consumption in relation to age

Figure 17 shows the different types and number of edible insects that are consumed by different age groups. Out of the five types of insects consumed in this community, respondents aged 18–49 consumed between two to four types of edible insects while those aged 50 and above consumed four to five types of edible insects (Figure 17). Female discussant number 28 said:

> *"It is different, old people eat a number of different types of insects but us young people are selective of the type of insects we consume. We follow energy in insects but old people just eat any type of insects."* (Female youth, focus group discussion 6)

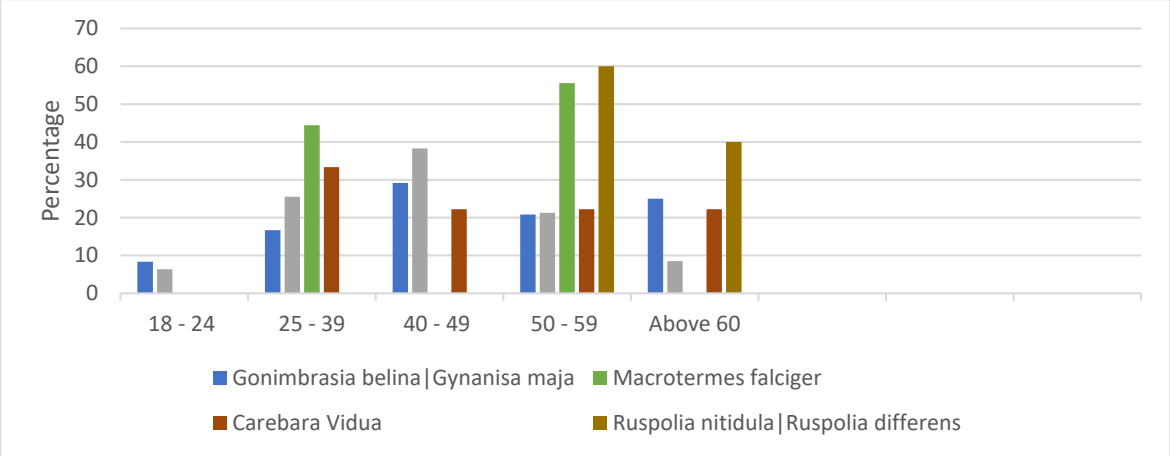

Figure 17. Type of insects consumed in relation to age.

Male discussant number 2 said:

> *"Most of us young people know that edible insects are rich in protein but what stops us from consumption is culture. It's not part of our culture to eat edible insects."* (Male youth, focus group discussion 1)

This may indicate that different food cultures may exist in this community between young and old people, and entomophagy was one of them. It was further mentioned that some young people liked eating caterpillars because they were nutritious while flying termites and African thief ants were popular among some young people because these insects were oily and had good texture. However, it was further mentioned that because grasshopper preparation for consumption needed some special traditional knowledge such as the removal of some body parts to make them less poisonous, many young people did not have this knowledge, hence avoiding eating grasshoppers.

5.4.2.2 Education

Figure 18 shows edible insect consumption levels among respondents of different education levels. Most (81%) of the respondents that attained tertiary education consumed edible insects while of those that attained secondary education, 54% consuming edible insects (Figure 18).

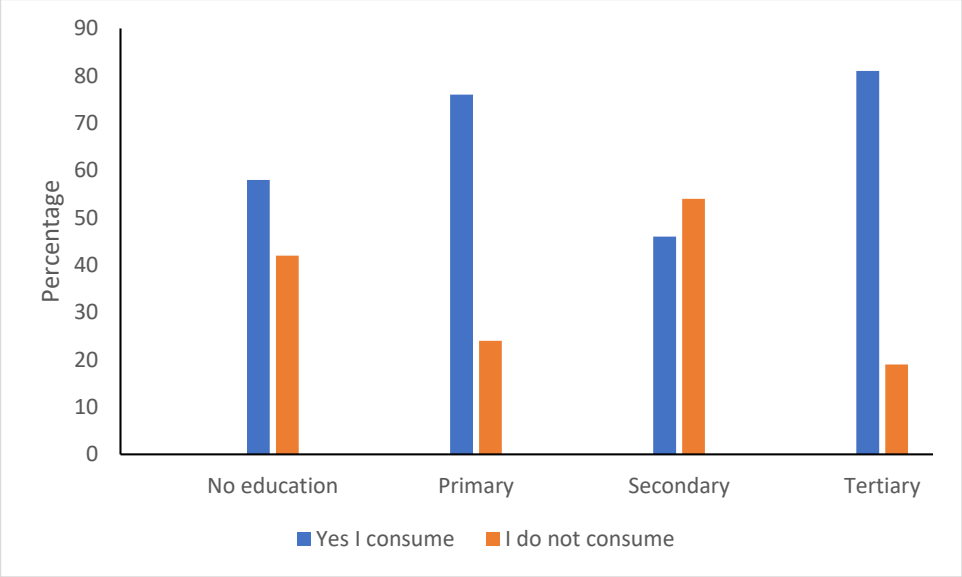

Figure 18. Insect consumption in relation to education level.

Out of the seven heads of household who consumed insects among the households that had no formal education, 57% cited taste as the reason for consuming insects, 29% culture and 14% nutrition, while out of the five respondents that did not consume insects in this education category, 40% cited religion as the reason, 40% allergies, and 20% not part of their culture. Out of 54 heads of household that consumed insects among the households that attained primary education, 52% cited nutrition, 21% culture, 19% relish, and 8% taste. Of the 17 heads of household that did not consume insects in this education category, 46% respondents cited allergies, 18% religion, 18% disgust, and 18% not of their culture. Out of 16 heads of household that consumed insects among the households that attained secondary education, 38% of the respondents cited culture, 31% nutrition, 19% relish and 12% taste. Of the 19 heads of household that did not consume insects, 37% cited allergies, 26% disgust, 21% not part of culture, and 16% religion. Out of 17 heads of household that consumed insects among the households that attained tertiary education, 59% cited nutrition and 41% culture while out of the four heads of household that did not consume insects in this education category, 3 cited religion and one allergy.

5.4.2.3 Income

Table 8 shows the relationship between income levels of various respondents and the number of respondents that consumed edible insects in each income category. The majority of respondents that had an income of above K20 000 ($769) consumed edible insects (75%) while 35% of those in the income category of K987–K5000 ($38–$192) did not consume insects.

Table 8. Pattern of insect consumption among respondents of varying income levels.

Income range	Yes, we consume	%	No, we do not consume	%	Total
K987–K5000	35	65	19	35	100%
K5000–K10 000	28	67	14	33	100%
K10 000–K20 000	19	70	8	30	100%
Above K20 000	12	75	4	25	100%
Total	94		45		139

Out of the 35 insect consumers that earned K987–K5000 ($38–$192), 51% consumed insects occasionally, 26% twice a week, 11% monthly and 6% once a week, while 6% did not indicate. Out of 28 consumers that earned K5000–K10 000 ($198–$384), 39% consumed insects occasionally, 29% twice a week, 18% once a week, and 14% monthly. Out of the 19 insect consumers that earned K10 000–K20 000 ($384–$769), 37% consumed insects occasionally, 21% once a week, 21% monthly, 11% twice a week, and 11% did not indicate. Out of 12 insect consumers that earned above K20 000, 42% consumed insects twice a week, 25% once a week, 17% occasionally, and 17% monthly.

Out of 35 insect consumers that earned K987–K5000 ($38–$192), 40% cited accessibility and availability as the factors that determined insect consumption in their households, 31% affordability, 11% availability, 9% accessibility, and 9% availability and affordability. Out of 28 insect consumers that earned K5000–K10 000 ($198–$384), 43% cited accessibility and availability as the factors that determined consumption in their households, 29% availability, 14% affordability, 11% availability and affordability, 4% accessibility. Out of 19 insect consumers that earned K10 000–K20 000 ($384–$769), 42% cited accessibility and availability as the factors that determined consumption in their households, 37% availability, 11% accessibility, 5% affordability, and 5% affordability and availability. Out of 12 insect consumers that earned above K20 000 ($769), 42% cited accessibility and availability as the factors that determined consumption in their households, 25% accessibility, 25% availability, and 8% affordability. This shows that accessibility and availability was the leading factor in the consumption of insects in all the four different income streams while affordability was the leading single factor among those that earned K987–K5000 ($38–$192), and availability among those that earned K5000–K10 000 ($198–$384).

5.4.2.4 Religion

In terms of religion, out of 108 Catholic households, majority (73%) consumed edible insects while 27% did not. Out of 18 Adventists, majority (67%) did not consume edible insects while 33% consumed. It was reported that those members of the Seventh Day Adventist (SDA) that consumed edible insects did so in defiance of their religious teachings because they believed that edible insects were a gift from God. For example, adult male discussant number 7 said:

> *"It becomes source of food. So, it will be more like God has answered, it is manna. So, it also plays a role in that manner."* (Male adult, focus group discussion 2).

Out of 11 Jehovah's Witness, 64% consumed edible insects and 36% did not. All (100%) respondents that followed African traditions consumed edible insects. Out of 29 Catholics that did not consume edible insects, 62% cited allergies, 24% as not part of their culture and 14% disgust. Out of 12 Adventists, 67% cited religion, and 33% allergies. All four Jehovah's Witnesses cited allergies.

5.4.2.5 Physical appearance

Although acceptance of insects in this community was generally high, there were variations based on the physical appearance of certain type of insects, particularly some species of caterpillars with spiked bodies that were resented by young people (Figure 19). For example, five out of 10 young (18–24 years) respondents that participated in the focus groups indicated that they disliked edible insects because their appearance was not appealing. Discussant number 28 said:

> "*The negative aspect is because some people like me don't eat edible insects because they are not appealing, they are not even appetizing."* (Female youth, focus group discussion 6).

Discussant number 2 said:

> *"Young people have bad perception about edible insect. They consider them as insects. For example, all of us here do not consume insects. For me I don't eat any of the edible insects because I look at them as insects. Their appearance is not attractive as such, my conscience does not allow me to eat."* (Male youth, focus group discussion 1).



Figure 19. Example of spiked caterpillars disliked by young people. The average length of these caterpillar is approximately 4 cm. These caterpillar are the larvae of *Charaxes jahlusa* Trimen 1862.

Some discussants indicated that although they did not get sick upon touching or consuming insects, they did not like their appearance. Additionally, it was observed that the caterpillar degutting process was time consuming as caterpillars had to be squeezed one by one. The degutting process was said to be disgusting and dirty as the material excreted stained both hands and clothes and caused the cracking of hands (Figure 20). Commenting on this matter, discussant number 1 said: *"In terms of caterpillars, the degutting process is messy, it is disgusting."* (Male youth, focus group discussion 1).



Figure 20. Picture of stained hands of a caterpillar collector during degutting process.The average length of the dugeted *Gynanisa maja* catepillars is approximately 2.5 cm.

In addition to the physical appearance, it was mentioned that some people developed allergic reactions after consuming insects, and this made some people unwilling to consume insects. It was reported that some insect species such as caterpillars caused body swelling, itchiness, vomiting, and bleeding when consumed. Discussant number 26 said:

> *"The biggest worry is that when consumed, some people develop swollen faces, body itchiness and rushes. Like in my case, I don't eat because I itchy a lot and develop rushes when I eat flying termites but I don't react when I consume caterpillars"* (Female youth, focus group discussion 6).

Out of the 45 respondents that did not consume edible insects, 38% respondents cited allergies. However, it was mentioned that it was not all edible insects that cause allergic reactions. Additionally, it was further mentioned that different insects tasted differently, as such some people preferred consuming certain types of insects over others. It was also mentioned that although insects were nutritionally valuable, they tasted differently from one type to another

which caused people to have varying preferences for different insects. For example, it was mentioned that caterpillars had a better taste than flying termites. Discussant number 27 said*:*

> *"Some people may not eat African thief ants but they may eat flying termites because flying termites have a better taste than African thief ants."* (Female youth, focus group discussion 6).

It was further observed that because edible insects were harvested from the wild and far from human settlements, most people thought they were safe to consume. For example, it was observed that caterpillars were collected from forests in Ngabwe district, 80 km northeast of Kaindu, and grasshoppers, flying termites and thief ants were collected from grasslands and rangelands located within 2–3 km from homesteads. Discussant number 22 said: *"Those things are found in the bush far away from human settlements, that's why we go to collect them. They are found up in the trees, not on the ground."* (Male adult, focus group discussion 4). This indicates that concerns of safety from biological or chemical hazards were not factors that prevented people from consuming insects. However, it was mentioned that to minimize the possibility of poisoning, some body parts of certain insects were removed during their preparation. For example, discussant number 20 said: *"It is some body parts of the insects that are poisonous. For example, the head of a thief ant if not properly handled can cause problems, it contains poisonous stuff"* (Male youth, focus group discussion 5). The community had knowledge of the type of insects that were likely to be poisonous and the methods of minimizing such risks. Although chemicals and pesticides were used on legumes and cotton fields in this community, there was no reported case of poisoning or contamination that could prevent people from consuming insects found in agricultural areas.

5.4.2.6 Cultural background, traditional and ecological knowledge

Edible insects were treated differently among different ethnic groups in the Kaindu community due to their different cultural values and background. Among the Kaonde and Lamba speaking people in the area, consumption of edible insects was a symbol of cultural pride and identity. The types of insects used was related to the tribe that consumed them, so this led to spatial variations in the type and extent of insect consumption in the community. The area Councilor said:

> *"Insects are related to type of people who live in that area of course they differ from place to place. So, you can tell that the people who live in this area feed on this type of edible insects. You are able to tell that these types of insects are in this*

group. In this area, most of them its Kaonde's and Lamba's. So you can tell to say, when you go to the Kaonde people, they feed on these. So, insects that are consumed depend on the tribe." (Key informant interview, Kalwanyembe ward Councilor).

Owing to the fact that in this community entomophagy was part of the local food culture because of their historical background, local Kaonde and Lamba speaking people felt the need to maintain the dietary and cultural practices of their forefathers. Emphasizing the need to preserve ancestral practices and traditional knowledge, discussant number 15 said: *"Edible insects are part of the local culture, it started with our forefathers, to our parents and we children are following in the footsteps of our forefathers."* (Female adult, focus group discussion 3).

On the other hand, it was reported that some tribes that were not indigenous to this community such as the Lozi speaking people did not consume insects like caterpillars, flying termites and grasshoppers, because they considered insects to be food for ethnic groupings inferior to themselves. Cultural pride and the need to maintain such cultural values and beliefs have influenced insect consumption among different tribal groups within this community. It was noted that ecological knowledge on where certain insects are found influenced insect consumption because of the location of different tribal groups in areas that support only certain types of insects. Likewise, if certain insects were absent in that area, local people did not necessarily have knowledge about them. For example, discussant number 8 said:

"In my case where I come from, we don't know these [edible insects]. Most of them, Western province where I come from it's a plain. In the plains we do not have the bush where we can catch that and our tribe does not allow according to our culture. And there is that assumption to say this type of food is consumed by the Mbundas. Mbundas are a different tribe where I come from" (Male adult, focus group discussion 2).

It was observed that Lozi speaking people did not possess traditional knowledge of edible insects found in agricultural and forest area, including caterpillars and flying termites because in the Western province, the region where Lozis come from, grasslands are present which are not host to such insects. However, it was observed that due to the dominant local culture, some families from tribes that did not originally consume insects had adapted to the local culture and started consuming edible insects. Discussant number 6 said *"But it does not mean that it's all*

Lozis that do not eat. Others have come to learn or adapt to the environment, just a few do not eat." (Male adult, focus group discussion 2).

In addition to cultural background and traditional ecological knowledge, it was noted that other taboos surrounding the consumption of certain insects are also important. It was reported that in some tribes, particularly the Lozi speaking people, men were not allowed to consume caterpillars because they believed that consuming caterpillars would negatively affect their libido. For example, discussant number 7 said: *"As a man when you eat these (caterpillars) your manhood won't be strong, it would be flabby or soft just like the caterpillar itself".* (Male adult, focus group discussion 2).

5.4.3 *Health benefits of insect consumption*

Besides using edible insects as a source of food and nutrition, 10 out of 29 respondents that participated in the focus groups said that they preferred edible insects because they considered them healthy and natural foods. Food that was harvested from the wild was generally considered as being clean and with low risk of diseases, so consumption of edible insects was seen as one way of improving one's health. People were encouraged to consume edible insects that feed on leaves which people believe have medicinal properties. Focus group participants mentioned that an increase in diet related diseases was linked to the consumption of foods that were not natural or organic, such as domesticated fish and broiler chickens that were fed on synthetic feed. Edible insects were perceived as foods that may reduce diet related diseases as well as increase one's lifespan. For example, discussant number 23 said:

> *"Lately, we consume fish that is fed on feed, a lot of other foods that we don't know properly, but if we continue following our cultural practice of consuming edible insects, we will reduce disease burden as well as increase people's life span."* (Male youth, focus group discussion 5).

It was further observed that because insects fed on natural vegetation (tree leaves and grass), they are nutritionally better than meat, poultry and fish and their consumption produced positive results in a short period of time. For example, discussant number 24 indicated that:

> *"The problem with fish, is that I can eat for the whole month but I won't change. With insects, change will be visible within a month. Especially when you dry them and pound them, if given to children as porridge, they grow up very healthy, they*

don't get sick frequently. They are healthy, people even admire how healthy a child looks because of caterpillars" (Male youth, focus group discussion 5).

Thus, insect consumption was done with a sense of pride because they are considered to be natural or organic foods whose frequent consumption helped to reduce lifestyle diseases. For example, discussant number 7 said: *"Many people here like harvesting food from the wild because they are considered health. Edible insects are considered to be health and natural food."* (Male adult, focus group discussion 2). It was also mentioned that certain insects were used as medicines. The area Councilor said: *"When you are suffering from diarrhea or stomach upsets, when you eat bee larva or pupa you get better. They are very good for abdominal upset"* (Key informant interview, Kalwanyembe ward Councilor). However, it was mentioned that adult bees did not have medicinal properties but were consumed as relish.

5.4.4 *Impact of modernization on the consumption of edible insects*

It was observed that some young educated people openly despised consumption of edible insects as they mentioned that it was a backward practice and unacceptable in modern society. For example, two out of five young educated male respondents that participated in the focus group discussion attributed the non-consumption of insects particularly among the young educated people to the western food culture as a standard measure of modernity and civilization. Discussant number 3 said: *"Young people are more interested in western lifestyle than their own culture because western culture is what is common and trending."* (Male youth, focus group discussion 1). Commenting further on the influence of modernity and how it negatively affected consumption of edible insects particularly among young people, the area Councilor said the community was facing difficulties in preserving entomophagy because it was perceived as an old practice. It was mentioned that because of the modern lifestyle, young people were beginning to shun consuming insects in preference to other foods that were considered more modern: For example, the Councilor said:

"It has actually changed beliefs and the way we take these insects. Some have even started refusing especially our children, they can't. They are saying no this was for the elders, we can't eat caterpillars, no, no, no, this was old fashioned." (Key informant interview, Kalwanyembe ward Councilor).

It was further observed that edible insects were not discussed or taught during traditional and initiation ceremonies due to the changing cultural environment. It was mentioned that most of

the young people did not show interest in acquiring traditional or cultural knowledge about edible insects. For example, discussant number 4 said *"Young people are being lazy. They are not interested in acquiring traditional or cultural knowledge about edible insects."* (Male youth, focus group discussion 1).

However, it was observed that most of the young people did not make decisions on food choices on a daily basis because it was the responsibility of the head of household. The dependency of young people on their parents inadvertently introduced them to the consumption of edible insects. For example discussant number 5 said:

> *"Most young people in our community are kept by their parents, they don't have financial independence, so whatever the head of the household decides that should be prepared as food, they have no option but to eat. Parents determine the food we eat. That's why a lot of young people end up eating edible insects because parents determine what we eat at home on a daily basis."* (Male youth, focus group discussion 1).

5.4.5 *Sources of knowledge about edible insects*

Out of 94 heads of household that consumed edible insects, 69% of respondents said they had a history of consuming insects from childhood whereas 31% only starting doing this as adults. Of these 94 heads of household, 62% learnt about edible insects from family, 20% from social interactions, 15% from traditional knowledge, and 3% through formal education.

Social interactions in the community played an important role in influencing people, especially young people, who did not have the history of insect consumption to start doing so. For example, 13 out of 29 respondents that participated in focus group discussions indicated that they had noted an increase in the number of people consuming insects which they attributed to socialization among people of different backgrounds. For example, discussant number 3 said: "*There are people that never used to eat but they now eat. For example, my elder brother never used to eat any type of edible insects but he now eats caterpillars."* (Male youth, focus group discussion 1). Discussant number 2 said:

> "*There are young people that are non-Kaonde and never used to eat edible insects, but once they start interacting with local people, they start consuming edible insects because of social interaction. Most young people do not consume edible insects but*

with time and through interactions, they start consuming insects." (Male youth, focus group discussion 1).

It was mentioned that some people who had migrated to the community from surrounding towns such as Kabwe and Kapiri-Mposhi started consuming insects upon interacting with the locals.

5.4.6 *Methods of insect preparation*

Out of the 94 heads of household that consumed edible insects, 48 fried their insects, 24 boiled, 19 smoked, and 3 toasted. Of the 48 heads of household that fried insects, 24 mentioned taste as the preferred food characteristic, 17 palatability, and 7 texture. Out of the 24 heads of household that boiled insects, 17 preferred to do this to improve palatability while 7 did it to improve their texture. Out of the 19 households that smoked their insects, 12 respondents cited taste, 3 preservation, 2 texture, and 2 palatability. All the three households that toasted their insects cited taste as the reason (Figure 21). Out of the 48 households that preferred frying insects, 28 fried *Gonimbrasia belina/Gynanisa maja* (caterpillars), 13 *Macrotermes falciger* (termites), 5 *Ruspolia nitidula/Ruspolia differens* (grasshoppers), and 2 *Carebara vidua* (termites). Out of the 24 households that preferred boiling insects, 11 boiled *Macrotermes falciger*, 7 *Gonimbrasia belina/Gynanisa maja*, 4 *Ruspolia nitidula/Ruspolia differens*, and 2 *Carebara vidua*. Out of 19 households that preferred smoking insects, 7 *Gonimbrasia belina/Gynanisa maja*, 6 *Macrotermes falciger*, 4 *Carebara vidua* and 2 *Ruspolia nitidula/Ruspolia differens*. Out of the three households that preferred toasting, 2 *Macrotermes falciger*, and 1 *Ruspolia nitidula/Ruspolia differens*.

Through participant observations in their homes, it was also observed that *Macrotermes falciger* (Termites), *Carebara vidua* **(**African thief ant**)** and *Ruspolia nitidula/Ruspolia differens* (Grasshoppers) were blanched or steamed for few minutes then sun-dried or toasted in their fat, after which they removed their wings. Salt was also added when blanching or steaming. It was observed that different preservation methods were used for different insects. *Gonimbrasia belina/Gynanisa maja* (Caterpillars) were blanched then sun-dried or toasted in hot ash while *Macrotermes falciger* (termites), *Carebara vidua* **(**termites) and *Ruspolia nitidula/Ruspolia differens* (Grasshoppers) were blanched and then sun-dried. Blanching and sun-drying were the most common methods of preservation. However, some people complained that insects did not

have long shelf life even after treating them for preservation. Discussant number 13 said: *"They also go bad easily, I don't know if there are chemicals that are used to preserve them, and we don't have those chemicals."* (Female adult, focus group discussion 3).



Figure 21. Edible insects being prepared for consumption. (A) *Macrotermes falciger* being toasted on a pan to be used as relish after cooking and removing the wings. (B) Toasted *Macrotermes falciger* and vegetables (*rape*) accompanying pap as relish served for lunch by one of the families in Kaindu.

Out of 48 heads of household that preferred fried insects, 81% were males and 19% females. Out of the 24 heads of household that preferred boiled insects, 54% were females and 46% males. Out of 19 respondents that preferred smoked insects, 84% were males and 16% females. Out of the nine that preferred toasted insects, 78% were females and 22% males.

It was also observed that insects were not only consumed as relish but also as snacks among different people after being cooked. For example, it was observed that some women would carry a handful of caterpillars or termites and start eating while walking to the streams or wells to fetch water. Discussant number 12 said: *"For me, I always carry some when going to fetch water and eat on the way."* (Female adult, focus group discussion 3). When eaten this way, insects were not pre-heated because they were already blanched and dried, making them ready to eat. It was further observed that some insects were pounded into powder, sieved to remove some particles, and added to maize meal or mixed with groundnut powder when making light

porridge for babies. This was done to enhance digestibility as children did not have fully developed teeth but more importantly to add protein to the cereals that were given to babies. Discussant number 14 said: *"Children don't have teeth, so they can't eat the whole insect, we have to pound them into powder to make it easy to chew."* (Female adult, focus group discussion 3). It was also observed that insects mixed with groundnut powder were also served as relish for main meals for adults.

5.4.7 *Insects, cultural values and the interpretation of nature*

It was mentioned that there were traditional beliefs or myths that surrounded the harvest of insects. For example, 24% of 29 respondents that participated in focus group discussions stated that people were forbidden to start collecting caterpillars, specifically *Gonimbrasia belina* and *Gynanisa maja* upon commencement of the caterpillar season without express authority from traditional leadership, particularly the chief, as defying the order would make one run mad. It was further mentioned that the Chief was not allowed to visit the bushes where insects, specifically *Gonimbrasia belina* and *Gynanisa maja* caterpillars were collected from as doing so would make caterpillars disappear. The discussants said that these beliefs were used as a means to reinforce traditional ways of managing insect resources and the environment. For example, it was observed that because people abided by the traditional beliefs surrounding the collection of caterpillars, there was a delay in the commencement of the harvest season which enabled the caterpillars to grow to a good size. It was further mentioned that certain conduct was prohibited in order to promote the presence of edible insects as failure to observe such traditional rules would make insects particularly caterpillars disappear. For example, discussant number 13 said:

> *"It is also forbidden for people to engage in sexual activities when they are collecting caterpillars. It is believed that once people engage in sexual activities, caterpillars won't appear in that bush anymore. So, maybe some people, misbehaved, that's why we can't have caterpillars here anymore. We are not following traditional rules anymore that is contributing to scarcity of caterpillars."* (Female adult, focus group discussion 3)

Thus, it was observed by the researcher that certain traditional beliefs were used to promote cultural morals. It was also reported that women who were menstruating were forbidden from

participating in the collection of *Gonimbrasia belina* and *Gynanisa maja* caterpillars. Discussant number 15 said:

> *"It is also forbidden for a woman who is menstruating to go in the bush to collect insects until she finishes, but the way it is nowadays, they argue to say who would feed them if they stay away. But those insects are sensitive, they know, so they won't appear."* (Female adult, focus group discussion 3).

It was further reported by some focus group discussants that when certain type of insects specifically *Gonimbrasia belina* and *Gynanisa maja* caterpillars or *Locusta migratoria* Linnaeus 1758 (Locust) appeared either in small or large quantities, they were traditionally interpreted as a message from God about the future rainy season and food situation. For example, it was reported that when *Gonimbrasia belina* and *Gynanisa maja* caterpillars appeared in abundance in a particular season, it was a sign that there would be less rain in that particular season, whereas abundant *Locusta migratoria* was a sign of hunger or less food to be harvested. Discussant number 7 said:

> "*They are also perceived to say, whenever those things… maybe caterpillars are seen, then there is a notion attached that maybe there will be hunger. When there are a lot of caterpillars it is believed that year, people will not have food or we won't be able to have a lot of rains. Especially old people, they are able to interpret the seasons with regards to what they see. With locusts also, it is believed that when there are a lot of them it means that there won't be a lot of rainfall. Sometimes you can even have, maybe three consecutive years without caterpillars."* (Male adult, focus group discussion 2).

It was also reported by some focus group discussants that although insects were also used as a medium for interpreting nature, this practice was not widely prevalent because few people believed in the traditional methods of predicting weather conditions.

5.5 Insect collection

5.5.1 Number of households that collected insects and the type of insects collected

Out of 139 questionnaires administered to heads of household, 63% collected edible insects while 37% did not. Of the 88 heads of household that collected insects, 57% collected *Gonimbrasia belina* and *Gynanisa maja* (caterpillars), 27% *Macrotermes falciger* (termites), 10% *Carebara vidua* (African thief ants), and 6% *Ruspolia nitidula* and *Ruspolia differens* (grasshoppers). Out of 50 householders that collected *Gonimbrasia belina* and *Gynanisa maja*,

62% were older people (50 years and above) while younger people (18–49 years) were the minority (38%). Out of 24 householders that collected *Macrotermes falciger*, 62% were younger people while there was none in the category 50 years and above. Out of nine people that collected *Carebara vidua*, 67% were young people (18–24 years) while older people (50–59 years) represented the minority (33%). Out of five people that collected *Ruspolia nitidula* and *Ruspolia differens*, 80% were young people (18–24 years) while older people (50–59 years) were the minority (20%).

5.5.2 Sources of edible insects

Out of 50 heads of household that collected *Gonimbrasia belina* and *Gynanisa maja*, 40% collected them from Ngabwe district which is about 180 km northeast of Kaindu while the minority (10%) collected from the local vicinity within 0.5 km radius from their homes (Table 9). It was observed that people who collected *Gonimbrasia belina* and *Gynanisa maja* from Ngabwe and Kasempa did so in order for them to have surplus quantities so that they could sell and raise income because it was in Ngabwe and Kasempa districts where *Gonimbrasia belina* and *Gynanisa maja* caterpillars were found in huge quantities as they were scarce locally. For example, female discussant number 14 said:

> *"But now they are not available. Only in far places and this is when insects are fetching a lot of money. Caterpillars are only available in distant places."* (Female adult, focus group discussion 3).

It was further observed by the reasher that those that collected caterpillars from within Kaindu community collected other caterpillar species such as the Pallid emperor moth, *Cirina forda* Westwood 1849 locally known as 'Mishyankonko', which were unpopular in the community (Figure 22b). Table 9 shows various places were common edible insects *Gonimbrasia belina*, *Gynanisa maja, Macrotermes falciger, Carebara vidua*, *Ruspolia nitidula* and *Ruspolia differens* in this community were sourced from. Ngabwe district was the major source of caterpillars while flying termites, thief ants and grasshoppers were sourced from the local area

Table 9. Sources of different types of edible insects for the Kaindu community.

Source	*Gonimbrasia belina* and *Gynanisa maja*		*Macrotermes falciger*		*Carebara vidua*		*Ruspolia nitidula* and *Ruspolia differens*		Distance (km)
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	

Ngabwe	20	40	8	33	0	0	0	0	180
Kasempa	16	32	5	21	0	0	0	0	200
Local forest	9	18	0	0	0	0	0	0	35
Local vicinity	5	10	11	46	9	100	5	100	0.5
Total	50	100	24	100	9	100	5	100	

Different species of caterpillars were collected for consumption. These includes caterpillars identified as 'Tubambe' (Emperor moth, *Gonimbrasia metanops* Bethune-Baker 1908), 'Mishyankonko' (Pallid emperor moth, *Cirina forda* Westwood 1849), 'Sokosoko' (Mopane worm, *Gonimbrasia belina* Westwood 1849), and 'Mafuke' (Speckled emperor moth, *Gynanisa maja Klug* 1836) (Figure 22). It was observed by the researcher that *G. belina* and *G. maja* caterpillars were collected from Ngabwe and Kasempa because that is where they were found in abundance, whereas *C. forda* were mostly picked from the bushes within the community and mostly by elderly women because it was easier for them to collect them (Figure 23).

It was further observed by the researcher that out of the four-caterpillar species that were consumed in this community, *Gonimbrasia belina* and *Gynanisa* caterpillars were the most consumed species while *Cirina forda* caterpillars were unpopular among young people because they considered them to be poisonous and the hairy spikes caused allergic reaction.

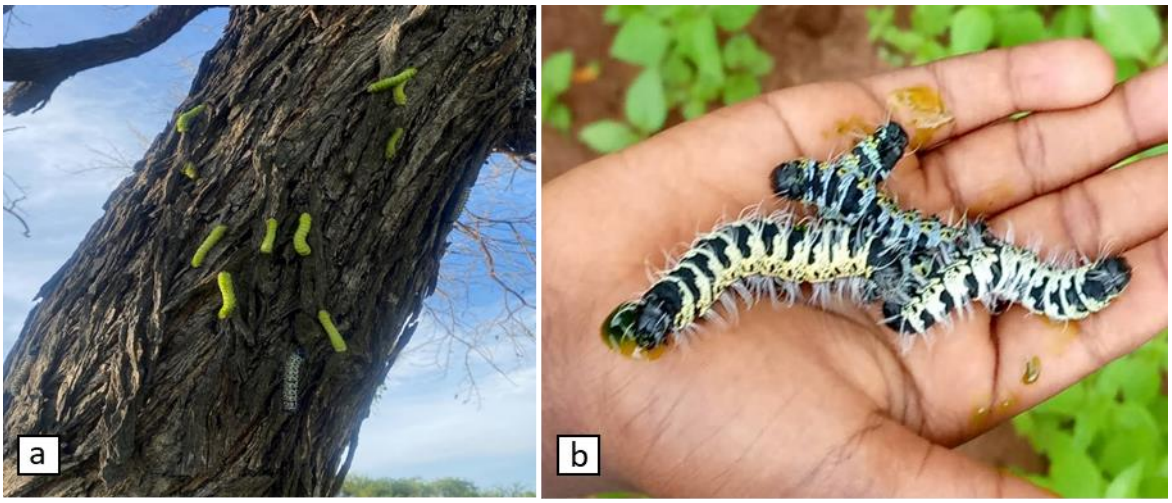

Figure 22. Some of the caterpillars consumed in the Kaindu community. (A) live *Gonimbrasia belina* and *Gynanisa maja* catepillars sticking to a tree trunck. (B) *Cirina forda* caterpillars, measuring approximately 3 cm long, being harvested within Kaindu community.



Figure 23. An elderly woman picking *Cirina forda* caterpillars from bushes around her homestead in Kaindu.

It was observed by the reasearcher that men dominated the collection of caterpillars because the collection process was time consuming as people were required to either climb trees in order to collect caterpillars or wait until caterpillars came down the tree branches to the ground (Figure 24). It was also observed by the reseacher that the process of tree climbing or cutting down trees hosting caterpillars was laborious and mostly involved men, while women and young people collected caterpillars from the ground. Some bushes where caterpillars were collected from were sometimes not physically safe and not easy to reach due to thickets and lack of access paths.



Figure 24. *Gynanisa maja* caterpillars measuring about 3.5 cm long hanging on small shrubs.

It was also observed by the researcher that some collectors preferred picking caterpillars which had come down from trees to the ground because they believed that then they were at the right developmental stage to be harvested (Figure 25). For example, discussant number 21 said:

> *"There is a period when caterpillars come down from the trees and start moving on the ground. That's when I think people should start collecting, when they start coming down the trees, they are even fat and big, they are fully matured."* (Male adult, focus group discussion 4).



Figure 25. Example of mature *Gynanisa maja* caterpillar measuring about 7 cm long found on the ground.

Macrotermes falciger were mainly collected by young boys and male youths late at night, mostly after midnight, as that is the time when they would normally start appearing from anthills. Illuminating light traps such as fires, electric or solar bulbs and phone torches were used to lure insects into collection utensils such as open plastic containers that were filled with water. Lighting points were limited as only public places such as schools and health facilities had electric power supply while private homesteads used phone lights, candle or fires to attract *Macrotermes falciger* (Figure 26). However, the lack of adequate lighting points contributed to low volumes of flying termites being collected. After collection, *Macrotermes falciger* were sorted to remove unwanted contaminants such as leaves, grass and other insects which swarm together with the termites.

Collection of *Carebara vidua* was done in the morning by both young boys and girls between the ages of 7 to 16 from anthills in nearby bushes as *Carebara vidua* come out of their holes when the sun starts heating up. The young collectors would chase and catch flying *Carebara vidua* or wait by the antihills where they would snatch Carebara vidua as they came out of the antihills and put them in a container with a tight lid. *Ruspolia nitidula* and *Ruspolia differens* were collected from either the maize fields or grasslands within the community in the morning by boys, mostly aged between 7 to 16.



Figure 26. A fire lit at night at one of the homesteads to help attract *Macrotermes falciger*.

5.6 The contribution of edible insects to household livelihoods

5.6.1 Number of households that participated in the insect trade

Out of 139 questionnaires administered to heads of household, 74% indicated that they did not participate in the sale of edible insects while 26% did participate in this. Of the 36 heads of household that sold edible insects, 75% sold *Gonimbrasia belina* and *Gynanisa maja* (caterpillars), 19% *Macrotermes falciger* (flying termites), and 6% *Ruspolia nitidula* and *Ruspolia differens* (grasshoppers). Of these 36 households that sold insects, 67% generated an income of K1000–K2000 (about $38–$75), 5% K2000–K4000 (about $75–$151), 6% K5000–K10 000 (about $189–$377), and 3% above K10 000 ($377). Of these 36 households, 44% cited high market prices as the reason for selling edible insects, 39% demand for edible insects, and 17% because of insect availability. In addition, 56% of the traders sold their insects during off season when prices were higher, while 44% sold them during the harvest season itself.

Out of 103 respondents that did not participate in the sale of edible insects, 41% cited lack of adequate quantitities of insects, 36% the long distances to suitable harvest sites, and 23% a lack of interest.

5.6.2 Edible insect trade as an emerging alternative source of livelihood

In this community, it was reported by the focus group discussants that edible insects were a source of livelihood as they generated enough money from trading. It was reported that people were getting increasingly involved in insect collection and trade as alternative source of household income. For example, 48% of 29 respondents that participated in the focus group discussions indicated that people in this community were paying less attention to traditional agriculture because they realized little economic benefits compared to the sale of edible insects. Discussant number 4 said: *"Many people do not pay much attention to agriculture. So, some people survive on collecting edible insects. They make business out of edible insects."* (Male youth, focus group discussion 1).

It was observed by the researcher that some people that collected caterpillars exchanged them for bags of maize which they either kept for food or sold on. It was further reported that the income generated from the sale of insects, especially caterpillars, was much higher than maize as a 5-litre bucket ('meda') of caterpillars sells for around K300 (about $11) during the harvest season and K500 (about $19) when off season and in some cases, the income was higher depending on the type and quantity of the caterpillar species being sold while the same quantity of maize grain sold for K20 ($0.75) during harvest season (June–August) and K50 ($2) off season (October until the next harvest season). It was further mentioned that income generated from the sale of edible insects was used for the purchase of farming inputs such as fertilizers and seeds, groceries and food. For example, out of 36 heads of household that participated in the insect trade, 58% used their income on the purchase of food, 28% for groceries, and 14% for farm inputs. Discussant number 15 said:

> *"When you collect in excess you can be able to sell to people who didn't collect. That money helps, even when you didn't have cooking oil and salt at home, you will be able to buy from proceeds of insect sales. You can even be able to pay school fees for children including books."* Female adult, focus group discussion 3)

In the same vein, discussant number 2 said:

> *"We have seen homes where the family is not doing fine. But you find that after they have gone to collect, after this season, the family is even able to have 3 meals a day. You are able to see children going back to school. You can see at least the decency."* (Male youth, focus group discussion 1)

5.6.3 Urban cities as new market places for edible insects

Out of 36 heads of household that participated in insect trade, 53% sold their edible insects in Lusaka district about 280 km west of Kaindu community, 33% in Mumbwa town 80 km west of Kaindu, and 14% in Copperbelt Province, about 330 km east of Mumbwa district while none sold within the Kaindu community.

It was reported by the focus group discussants that insect collectors from the local rural communities preferred selling their insects to wholesale traders from urban areas because they offered higher prices than traders from within the local rural communities. Discussant number 7 said: "*They catch caterpillars and take to cities like Lusaka to go sale. They make good money. Even flying termite, people take them to urban markets."* (Male adult, focus group discussion 2). It was also reported that it was difficult for some local people to venture into insect retailing in rural communities because most insect collectors had specific wholesellers from urban areas. It was further mentioned by the discussants that some harvesters even had specific and permanent clients who they sold their insects, owing to familiarity and trust they built with them over time. For example, discussant number 1 said: *"People come from far places like the Copperbelt and Lusaka to come buy caterpillars. Local harvesters even have permanent clients who they sale caterpillars to. They do not just sale anyhow or to any other person."* (Male youth, focus group discussion 1).

Because of the increasing demand for edible insects in urban areas, it was difficult to find insects being sold in rural areas. Discussant number 11 said: *"Here you may not find caterpillars but when you go to town, you will find caterpillars are available being sold, yet they are collected from here. So, it is sellers in urban areas who are benefiting a lot from edible insects."* (Female adult, focus group discussion 3). This shows that demand for edible insects in urban areas caused distortions in distribution and availability of these insects in rural areas. For example, the researcher observed by the researcher that in Lusaka edible insects such as caterpillars and flying termites were sold in some markets and streets of the Central Business District while these insects were not found at Kaindu market (Figure 27).



Figure 27. Edible insects being sold in urban areas. (A) *Gonibrasia belina* caterpillars being sold at Kulima tower bus station in the Central Business District of Lusaka. (B) Woman selling *Macrotermes falciger* along Katondo Street in the Central Business District of Lusaka.

It was further observed by the researcher that some people from Kaindu community expressed concern with the reported bias in insect trade as it caused unfair competition in accessing insect resources that could have enabled the local community to benefit from them financially. For example, 4 out of 29 focus group discussants mentioned that traders from urban areas benefited more from insect resources than local people. Discussant number 14 said: *"Us are the ones that used to collect insects locally but now we are the ones buying, we don't benefit from edible insects locally."* (Female adult, focus group discussion 3).

Besides traditional markets, it was observed that *Gonimbrasia belina* and *Gynanisa maja* caterpillars were now being sold in some of the supermarkets in urban areas (Figure 28). This is a new development as previously edible insects were only sold in traditional markets and on street corners in urban areas. However, it was observed that only one type of caterpillar species (*Gonimbrasia belina*) was sold in chain stores. Although caterpillars were sold in labelled pre-packs, the packs did not contain nutritional information or warnings of allergens.



Figure 28. *Gonimbrasia belina* caterpillars being sold in Choppies supermarket in Mumbwa town for different prices starting from K50 ($1.92) for 162 g and K60 ($2.30) for 202 g.

5.7 Factors threatening sustainable utilization of edible insect resources

5.7.1 *Reduction in insect population*

Out of 139 questionnaires administered to heads of household, majority (75%) respondents indicated that they had noted a reduction in insect availability, 10% did not notice any change, and 15% did not know whether there was a change or not. Of 29 respondents that participated in focus group discussions, majority (52%) mentioned that there was a reduction in the quantities of insects harvested in recent years as compared to the past (Figure 29). It was indicated by some focus group discussants that in previous years people used to collect 10 by 50 kg of caterpillars which they would take to the market, but this is less commonly now the case. For example, discussant number 20 said *"For caterpillars* (Gonimbrasia belina and Gynanisa maja)*, we are able to collect a bag or two but for flying* termites (Macrotermes falciger) *it's not possible, you can't manage to even collect a gallon."* (Male adult, focus group discussion 4). It was further reported that the reduction in edible insects was also for insects in general, but the most affected edible insects are *Macrotermes falciger* (termites) and *Ruspolia nitidula* and *Ruspolia differens* (grasshoppers). For example, during field observations conducted in the month of December, it was observed by the researcher that there were no *Ruspolia nitidula* and *Ruspolia differens* grasshoppers and *Carebara vidua* termites which was reported not to have been the case previously.



Figure 29. Quantities of different insects harvested. (A) Man displaying dried *Gonimbrasia belina* caterpillars stored in a sack which he collected over a period of two days. (B) The quantity of *Macrotermes falciger* termites caught after an hour under solar lighting at Kaindu Primary School in Kalwanyembe ward.

It was further mentioned by some focus group discussants that the reduction in insect population was causing price increases whenever insects (*Gonimbrasia belina, Gynanisa maja* and *Macrotermes falciger*) were available for sale. Discussant number 6 said:

> *"Even in this market, for example, in the last 2 to 3 years I have not seen caterpillars. Those other years they used to sale caterpillars just by this market. But this time they are not available; they are not seen."* (Male adult, focus group discussion 2)

This shows that the reduction in the overall insect population is impacting on food security and livelihoods owing to the fact that most households in this community consumed insects. It was reported that previously local people used to collect edible insects in large quantities from the backyard of their homesteads or within a short distance from their households but now they have largely disappeared from the community. The area Councilor said:

> *"This is not how it used to be, in the 1980s we used to collect honey less than 1 kilometer from home, but this time you have to move 5 to 10 kilometers for you to get honey, the same with caterpillars we used to collect them 10 meters away from our door steps, but this time you have to move."* (Key informant interview, Kalwanyembe ward Councilor)

It was further observed by the researcher that because of insect scarcity at the local level, people were now required to travel long distances to collect insects. It was indicated that, currently, the community was not benefitting from edible insects due to changes in how insects were being accessed. For example, discussant number 14 said: *"Currently, there is less benefit but previously we used to benefit a lot. Because we used to collect them from within our locality. We would even collect with children."* (Female adult, focus group discussion 3).

5.7.2 *Factors causing reduction in insect population*

Out of 104 respondents that indicated that they had noticed a reduction in insect populations, 36% attributed this to habitat destruction, 33% to climate change, 22% to over-exploitation, and 9% to non-adherence to certain cultural practices.

5.7.2.1 *Habitat destruction*

In terms of habitat destruction, it was observed by the researcher that there was expansion of agricultural activities as new agricultural fields were being opened up in places that were previously restricted and known to be habitats for edible insects. It was also observed that settlements were expanding into areas which were previously restricted or were conservation areas. The area Councilor said: *"Where we used to catch caterpillars 10–15 years ago, you can't go there now. It's a field for someone."* (Key informant interview, Kalwanyembe ward Councilor).

It was mentioned in focus groups that in the 1980s the Kaindu community had a lot of thickets and forests where insects used to be found, but that these areas had now been converted to farms and housing, directly affecting insect populations. It was further observed by the researcher that habitat degradation was made worse owing to the fact that there was also no replanting of trees (Figure 30).



Figure 30. Some caterpillar-hosting trees cut down to create space for crop fields. The cut down trees were used to form charcoal, therefore contributing to the reduction in caterpillar population.

It was also observed by the researcher that anthills as habitats for termites were removed from agricultural fields. There was also indiscriminate late burning of grassland especially between August and October in order to facilitate growth of fresh grass for animal grazing, and this negatively impacts on insect. For example**,** discussant number 25 said:

> *"We have cut down all the host trees, we have destroyed habitat. Where we used to find edible insects previously, there are now crop fields and people are also living there. So that has caused edible insects to be scarce. Yes, because of increased human settlement and trees have been cut, anti-hills have been removed and all the land turned into farms."* (Male youth, focus group discussion 5)

It was noted that grasshoppers were mostly affected by the late burning of grasslands since this is mainly where they are found. For example, discussant number 7 said: *"For grasshoppers they grow in grass, once the grass is burnt then they are not there."* (Male adult, focus group discussion 2). This shows that environmental degradation through expanding agricultural land and settlements contribute to reduced insect availability in the community.

However, it was observed by the researcher that people in this community were knowledgeable on how environmental degradation, particularly deforestation, negatively affects insects. For example, 34% of 29 focus group discussants mentioned the need to protect habitats such as

forests and specific host trees to preserve nature and edible insects such as caterpillars. Discussant number 13 said: *"You see for caterpillars; they are not found in every tree. There are specific trees where they are found. But it's the same trees that charcoal burners want for charcoal, that's the problem."* (Female adult, focus group discussion 3). Discussants mentioned that it was important to preserve caterpillar host trees and to change from current harvest methods which were destructive. For example, discussant number 6 said: *"We also have to look at the collection methods also because most of collection methods compromise nature. You have to cut down trees and now when you cut down a tree, it will take ages for it to grow."* (Male adult, focus group discussion 2).

It was mentioned by some focus group discussants and the area Councilor that there were no mechanisms in place to restrict people from destroying habitat as the expansion of agricultural activities and settlements were not planned or regulated by government. It was indicated by the area Councilor that insect resources were neglected in the discussion of both ecological conservation and to guide developmental activities. The area Councilor said:

> *"So, there have been a lot of developmental activities here. You know where there is development some people tend to forget that even insects are also important, they will destroy everything, forgetting about other species, that's where there is a problem."* (Key informant interview, Kalwanyembe ward Councilor)

However, the area Councilor reported that a local non-governmental organization known as Community Markets for Conservation (COMACO) was working with local communities to help them conserve ecologically sensitive areas through the creation of community forests. Communities were given beehives to venture into beekeeping as an economic activity. Here, each village in the community was required to preserve one hectare or more of forest in order to qualify to be enlisted on the beekeeping project as well as qualify for carbon trading. The area Councilor said:

> *"COMACO has come to help the community so that sometimes we should have preserved forest, so COMACO is interested in carbon, carbon investing, so village headmen are being encouraged at least in every village there should be at least a portion of one hectare or so reserved for carbon. I think by doing so, will have insects to have chance to hide there."* (Key informant interview, Kalwanyembe ward Councilor).

The reservation of some land for conservation was also expected to help mitigate the declining insect population especially that edible insects in this community and Zambia as a whole are collected from the wild.

5.7.2.2 *Climate change*

Eight out of 29 respondents that participated in focus group discussions mentioned that they had noted a change in weather patterns in recent years causing delays in the start of the rainy season. This was interpreted by respondents as contributing to scarcity of edible insects in this community. For example, it was observed by some focus group discussants that rains now start late in December when previously they would start in October. Discussant number 14 said:

> *"The weather has changed. The way it used to be in the past is not the same as it is today. When rain comes, it comes very late but, in the past, it would start raining around 15th October. That's the time when insects would first appear especially caterpillars."* (Female adult, focus group discussion 3)

In this community, the first rains were locally referred to as "imfula ya finkubala" meaning rains that brought caterpillars, because in the past the first rains were linked to the beginning of the insect season, particularly *Gonimbrasia belina* and *Gynanisa maja* caterpillars. As a result of this change in rain seasonality and weather conditions, it was observed by the researcher that *Gonimbrasia belina* and *Gynanisa maja* caterpillars now emerge late in December while *Macrotermes falciger* and *Carebara vidua* termites were noted in January after the first rains in early December. Respondents also mentioned that the area now experiences inadequate amounts of rainfall and prolonged dry spells that cause *Macrotermes falciger* and *Carebara vidua* termites to delay emerging from their colonies. For example, it was observed by the researcher that termites would only appear when the area has experienced heavy rains while there was no noticeable presence of *Macrotermes falciger* and *Carebara vidua* termites when there was less rain. This shows that some only emerge once the colonies have received sufficient rain especially at the beginning of the rainy season. Thus, the availability of certain types of edible insects depend on the amount of rainfall received. Discussant number 8 said:

> *"Yes, poor rainfall, because those wait for water. They are down right now until when it rains and water reach where they are. That's when they know that upwards, there is somewhere they can get food. So, once water doesn't reach there, they won't come out. If you can even look at the pattern of flying termites and thief ants*

this year, it was bad, very poor. There were no proper flying termites because of the rains, dry spell. This year we never had where the rains rained heavily for three consecutive days. It would rain today, then two weeks that's when it rains again." (Male adult, focus group discussion 2)

5.7.2.3 *Over exploitation and cultural beliefs*

It was reported by some focus group discussants that insect harvesters, particularly those that harvested *Gonimbrasia belina* and *Gynanisa maja* caterpillars did not segregate the size or developmental stage at which these species of caterpillars were harvested. It was mentioned that *Gonimbrasia belina* and *Gynanisa maja* caterpillars were collected before reaching full maturity stages, hence possibly causing disruptions in their life cycle. For example, it was observed by the researcher that although moth butterflies were seen in this community, *Gonimbrasia belina* and *Gynanisa maja* caterpillars were not found locally (Kaindu community). Discussant number 13 said:

"When they cut down the trees to collect caterpillars, they harvest everything. They don't choose whether they are young or not." (Female adult, focus group discussion 3).

It was observed by the researcher that people in this community thought that it was caterpillars that were mostly over-exploited because they were economically important therefore harvested in big quantities so as to generate more income. It was also observed by the researcher and also mentioned by some focus group discussants that there were no controls put in place to regulate the amounts or quantity of insects that could be harvested in a particular area. However, in some instances, it was observed by the area Councilor that there was selective harvest of some insect species. For example, the Councilor mentioned that although *Apis mellifera* (honey bees) were also consumed as relish by the Kaonde-speaking people, they were not indiscriminately harvested but left to produce honey. It was further mentioned by the Councilor that honey combs were not tampered with or harvested prematurely until the bee-pupa grew into adult honey bees.

In terms of cultural beliefs, it was reported by some focus group discussants that *Gonimbrasia belina* and *Gynanisa maja* caterpillars had become scarce in this community because it was suspected that some people were not abiding or obeying some cultural traditions. Discussant number 15 said: *"Caterpillars are very sensitive, if people don't*

follow traditions they disappear. I think people in this community have not been following traditions that's why caterpillars have disappeared from here. For example, the chief is not supposed to visit the bust where caterpillars are found. We don't know, may be the visited the bush hence this scarcity." (Female adult, focus group discussion).

5.7.3 *Lack of standardization and infrastructure*

When edible insects (*Gonimbrasia belina*, *Gynanisa maja* and *Macrotermes falciger*) are sold in urban areas like Lusaka, they were mostly sold from traditional markets or busy streets which lacked good storage facilities to ensure the safety and prolonged shelf life of edible insects. Lack of storage facilities such as refrigeration or the absence of other means of preserving insects apart from drying negatively affects insect availability, as these types of traders were compelled to sell insects in a shorter period to avoid them going bad. They were not pre-packed, canned, frozen or labelled as a way of adding value. Discussant number 24 said *"That's why if we had good storage facilities, we could have been storing them for continuous use. What I mean is if we had a way of storing them so that we have them all seasons, the whole year."* (Male youth, focus group discussion 5).

In addition to lack of infrastructure to support insect preservation, it was further observed by the researcher that there was no standard pricing for edible insects as this was determined by the quantity, which was mostly by volume, and the willingness of the buyer or the consumer to negotiate the price. However, it was observed by the researcher that generally *Macrotermes falciger* termites were sold for K10–K50 (about $0.38–$1.88) and for both *Gonimbrasia belina* and *Gynanisa maja* caterpillars it was K50–K100 ($1.88–$3.77) for different sizes or volumes of metal and plastic cups as the unit of measurement was not specified (Figure 31).



Figure 31. Edible insects being sold in metal and plastic containers of different volumes at Kulima Tower market in Lusaka's Central Business District. (A) Female youth selling dried *Gynanisa maja* caterpillars in different quantities of volume starting from K50–K100 ($1.88–$3.77). (B) *Macrotermes falciger* termites in different quantities of volume being sold at prices starting from K10 to K50 (about $0.38–$1.88).

In terms of transport or access to caterpillar harvest sites, those that collected *Gonimbrasia belina and Gynanisa maja* caterpillars from Ngabwe and Kasempa districts used banana boats or pontoons to cross to the harvest sites as there were no connecting road infrastructure, making it difficult for people to have access to the area. Bicycles were also a popular mode of transport to these caterpillar harvest sites. Those without transport relied on harvesting *Cirina forda* caterpillars and *Macrotermes falciger* and *Carebara vidua* termites from the local community. A lack of water boreholes, wells or other water sources in the areas around where insects are collected from may compromise food safety because *Gonimbrasia belina* and *Gynanisa maja* caterpillars may not be washed fully after degutting and before they are partially boiled. However, some collectors of *Gonimbrasia belina* and *Gynanisa maja* caterpillars did not degut or boil them but toasted them in hot ash as a way of preservation (Figure 32).



Figure 32. A woman preparing *Gynanisa maja* caterpilars for toasting in hot ash without first washing them.

5.7.4 Conclusions

In conclusion, this chapter has shown evidence that there are varied uses of edible insects (*Gonimbrasia belina, Gynanisa maja, Cirina forda, Macrotermes falciger, Carebara vidua, Ruspolia nitidula* and *Ruspolia differens*) in the rural community of Kaindu, including using insects as food, a source of income, healthy lifestyle and human wellbeing. The evidence also showed that the usage of edible insects in this community has increased among people of different ethnicity because of socialization and nutritional considerations. However, young and educated people have more negative perceptions of edible insects as food because they wanted to associate themselves with modern and European food culture. There is also a lack of institutional frameworks to promote environmental stewardship in order to promote resilience and conservation of various ecosystems that host different edible insect species. For example, there was no land use plan formulated by the local authority to guide developmental activities or establishment of settlements in a manner that also considered ecological and environmental factors. It was reported by the area Councilor that Danish international development agency

(DANIDA) had formulated a 10 year land use plan for this community but it expired in 2008. Since then, no other land use plan had been formulated. The area Councilor said:

> *"We had one which was sponsored by DANIDA but it expired in 2008. However, this area is divided into two parts, traditional and state land. We have no control over state land as much of it is in private hands. When it comes to traditional land, this is where you find a lot of settlements and encroachments. However, in this community, much of the land is planned for agriculture, this is a farming community."* (Key informant interview, Kalwanyembe ward Councilor)

In addition to the absence of land use plan, there was also no presence of Forestry personnel in this community to monitor and guide conservation of forests which are known to be the host for different edible insect species. In contrast to wildlife and fisheries management, there was the presence of personnel both from the local community and Department of National Parks and wildlife (DNPW). Personnel from fisheries department also frequently visited the area from Mumbwa town to ensure that fishers were compliant. This shows that insects and insect ecosystems were not valued the same as other finite edible natural resources.

Chapter 6: ANALYSIS AND DISCUSSION

6.1 Introduction

This chapter discusses the empirical findings presented in Chapter 5. This includes an explanation of the meaning and significance of the main results of this study and contextualizes this discussion with respect to ideas and themes in the wider international literature. This chapter aims at analyzing and understanding the role of edible insects and their multiple functions to people in the Kaindu chiefdom of Mumbwa district in Central Province of Zambia. Although a particular focus is the contribution of edible insects to household food security and livelihoods, this chapter discusses the major demographic, societal and cultural factors that influence their use, including the perceptions, attitudes and knowledge of edible insects among different members of this community.

6.2 Rural food insecurity

6.2.1 Food insecurity and coping strategies for rural households

Food insecurity is one of the challenges that most rural areas in Zambia are currently facing. The Kaindu community is not exceptional because the majority of households (Figure 11) experienced food insecurity as they ran out of food at different periods of the year (Section 5.3.2), particularly in the period January–March which is the rainy season in this area. Food insecurity is worsened during this period because most households run out of maize stock, a major commodity used to produce maize meal (pap) which is a staple food for the majority of households (Section 5.3.5).

Food insecurity is also likely to be worsened due to lack of diversity of crops cultivated as the majority of households only cultivate two types of crops namely maize and soya beans (Section 5.2.1.3). This means that if there is failure or poor harvest in one type of crop, households may not have the capacity to generate income to supplement food purchases (Section 5.3.4). This means that since most people in this community rely on subsistence agricultural production for their own household food security (Figure 15), there is a need to diversify food as well as income sources. Resilience to food insecurity may be bolstered by crop diversification or having alternative food sources. For example, 43% of households that had access to food had alternative food sources such as gardening or wild food collection (Section 5.3.3). This demonstrates the effectiveness of multiple or alternative sources of food in combating food insecurity in rural communities.

Other than lack of crop diversity, food insecurity in the Kaindu community is likely to be worsened by the effects of changing weather conditions. For example, eight out of 29 respondents that participated in focus group discussion said that there have been delays in the start of the rainy season coupled with inadequate amounts of rainfall (Section 5.7.2.2). This may cause challenges to households that depend on agriculture alone, rendering them more vulnerable to food insecurity. This is demonstrated by the fact that most of the households that depended on agriculture were also food-insecure (Section 5.3.1). Gardening was the most widely used approach to bolster food security among food secure households. Growing vegetables and leguminous plants such as beans may help to increase food security under more erratic and lower rainfall because these plants may not require as much water to grow as maize does. However, if this is to be developed as a commercial opportunity there may be need to invest in irrigation facilities such as motor or lift water pumps or access to larger land areas. This capital outlay may be prohibitive to some households.

In this community, food insecurity was high among households headed by elderly people (Figure 12). This could be attributed to the fact that, in terms of food production, the modal demographic group that was involved in agriculture was the middle aged (Section 5.2.1.3). This means that demographic factors such as age were a factor in ensuring food security. This is because these likely correspond to larger and multigenerational households where unskilled but manual labour is available from family members, in particular from women and children (Ebile *et al.*, 2022). Older householders may be less involved in agriculture. This means that there is need to make the food production process, particularly domestic agriculture through gardening, less labour intensive to ensure that all demographic groups can be involved in agriculture to promote household food security. To further promote food security in this community, it would also be important to slow population growth or have smaller family sizes. For example, households with smaller family sizes, mostly headed by younger people were more food secure than households with bigger family sizes mostly headed by elderly people (Section 5.2.1.1, Figure 12). This indicates that a smaller population both at household and community level is likely to be resilient to food insecurity because resources would be adequately distributed. However, slower population growth may disadvantage rural communities because majority of the small scale farmers depend on manual and family labour to cultivate their fields, therefore, may need big families.

Contrary to the belief that women were more vulnerable to food insecurity due to gender inequalities (FAO and IPC, 2020), female-headed households in this community were more food-secure than male-headed households (Section 5.3.1). For example, the majority (91%) of male-headed households indicated that they ran out of food and managed to have two meals a day while 55% of female-headed households had three meals a day (Section 5.3.1). This may be due to the fact that female-headed households had smaller household sizes compared to male ones (Section 5.2.1.1), and that female-headed households depended less on agriculture as compared to male ones (Table 4). The majority (65%) of female-headed households also had a higher annual income of K10 000–K20 000 ($377–$755) (Table 5). This means that most female households had the capacity to purchase food when their own production had depleted. It may also be attributed to the entrepreneurial nature of most female households who were involved in insect collection, agriculture and informal businesses (Section 5.2.1.5). This may further indicate that women and men play key and different roles in maintaining food security as producers and through decision-making at the household level. Improved financial capacity may help rural households to enhance household food security as people may have diversified sources of income to help them purchase food when the need arises. In this community, access to adequate food among female headed households may be as a result of deliberate efforts by organizations such as the World Bank to empower women in order to close the gender gap in food production and food systems in Zambia. For example, the World Bank empowered 75 000 women in 10 provinces of Zambia targeting 51 districts including Mumbwa district by providing productive grants equivalent to $225, business skill training and savings groups (World Bank, 2021). However, high food insecurity levels in this community may indicate that current food security interventions in the agriculture sector such as the provision of agriculture inputs by government through the Farmer Input Support Program (FISP) may not be achieving their desired results.

A reduction of meals from three to two or one per day is used as a strategy to cope with food insecurity among households that did not manage to have food all year round (Section 5.3.3). For example, the majority (58%) of households reduced the number of meals per day so that they could prolong available food stocks (Section 5.3.4). However, this strategy may not be effective as people may still be subjected to longer periods of hunger and may lead to undernourishment and malnutrition. For example, children were cited as the most affected and vulnerable to hunger during periods of food shortages in this community (Section 5.3.2), thus that food insecurity may affect different demographics in different ways. The main period in

which households ran out of food (Section 5.3.2) could further contribute to food insecurity because this is the period when most people were cultivating their fields and planting seeds. The shortage of food during this period may lead to deficit of energy or physical strength needed to cultivate the fields.

To effectively manage food insecurity in rural areas, there is need to implement specific interventions targeting identified vulnerable groups such as the elderly and young people in order to promote adequate nutrition, health and child growth. This may be done through empowerment of vulnerable households with small livestock such as chickens and goats which may not require resources such as land and capital. Rearing of chickens and goats may help rural communities to diversify dietary and protein sources as most people depend on consumption of pap and vegetables only (Section 5.3.5) which may not be nutritionally sufficient to promote healthy and balanced diets. This may also call for alternative and diversified affordable sources of food. For example, 68% of the population in this community consumed edible insects, 11% fish, and 10% meat (Sections 5.3.5, 5.4.1). This may indicate the preparedness of the community to diversify their diets. It may further indicate a shift from relying on meat which is considered as the conventional source of protein to other cheaper sources of protein such as edible insects which are harvested for free (Section 5.4.1). The utilization of locally available wild resources as well as rearing small livestock may help rural communities meet their nutritional needs. For example, 74% of households in this community were already involved in keeping livestock, especially chickens, goats and sheep, while 13% were also engaged in wild food collection as a way of enhancing household food security (Sections 5.2.1.5, 5.3.3). This means that the local community were already finding alternative ways of ensuring food and nutrition security. To implement food sustainability, programs or projects may not require much resources because most households were already keeping small livestock and, as such, likely already have the knowledge and skills needed to implement this successfully. For example, most households in this community already owned land which may be used for grazing or rearing of free-range chickens. Owing to the fact that insect scarcity was one of the factors identified as inhibiting their consumption (Section 5.7.1), rearing of insects in controlled environments may help increase the availability of popular insects for human consumption (Ghaly, 2009) or for feed for livestock such as chickens (Gahukar, 2016) which otherwise forage for insects in the bush and are thus prone to predation.

Other than affordability and availability of common foods consumed in this community, distance to sources of these foods may also play a part in influencing household food security. For example, the majority of households sourced their food from around 6 km distance from their households (Section 5.3.5) despite local food production at the household level. This may indicate that people spend time and energy walking longer distances or using different transport modes in order to access certain foods. This may worsen food insecurity among certain groups such as the elderly who are already facing food insecurity in this community (Figure 12). Therefore, reducing distances to food sources may help mitigate food insecurity and develop greater resilience.

People are likely to consume everyday foods that are sourced locally. For example, the majority (58%) of households in this community consumed pap and leafy vegetables only (Section 5.3.5), of which the vegetables were sourced within a maximum distance of 6 km, whereas fish and meat were both sourced from beyond 6 km distance. Since these meats were sourced from longer distances, people were less likely to consume them or that they are regarded as foods for special occasions as compared to vegetables. This indicates that distance to common sources of food may influence community diets. A few people (1 %) of households purchased food in Mumbwa town, most likely because they were looking for certain foods that were not found locally. This means that reducing distance alone may not be enough to manage food insecurity but that there needs to be a variety of affordable food types at the local level. Diversified food types and sources may widen options for household food security. As the majority (62%) of households produce all or some of their own food, this suggests that developing strategies for household-level food resilience would be most effective in reducing food insecurity. The reason for this is that other food alternatives are purchasing of food from the market within the community or from Mumbwa town (Figure 15). However, this is problematic where food expenditure is the biggest additional expense for the majority (71%) of households (Section 5.3.4) despite 35% of households spending less than K400 ($15) per month on additional food (Figure 14). Currently, the price of staple foods in Zambia is increasing. For example, annual food inflation for the month of February 2024 was recorded at 14.1% from 13.7% in the previous month (www.zamstats.gov.zm) meaning that the purchasing power for most rural residents is not matching with the rate of commodity price increases. An outcome is that food insecurity is likely to worsen in communities where poverty is already high, hence the need to enhance food production, supply and distribution at a local level to promote food security.

However, although localizing food systems may offer an affordable and sustainable solution to food insecurity in rural communities, this strategy may worsen the challenges of lack of dietary diversity and nutritional security for rural households. For example, 58% of households in this community consumed pap with leafy vegetables daily (Section 5.3.5) with the general absence of protein. Lack of dietary diversity may render rural food systems vulnerable to food insecurity especially that rural areas lack adequate infrastructure such as good and reliable road network, storage, and market facilities that would help promote household food security. Exploiting wild edible insect resources may therefore have a key role in dietary diversity as well as household food security (Ghosh *et al*., 2018).

6.2.2 *The contribution of edible insects to household food security and nutrition*

In this community, 68% of the population consumed edible insects (Section 5.4.1) because they are considered to be culturally accepted, normal and important resources, and 44% of people in the community rated insects as an important source of food (Section 5.4.1). Similar to other studies that note a decline in entomophagy in some developing world communities (Hlongwane *et al.,* 2021), in this study it was noted that modernization (Section 5.4.4) and also as reported by the area Councilor (Section 5.4.4), had contributed to the reduction of entomophagy among young indigenous people, therefore changing the way entomophagy was being practiced in this community. However, there was an increase in the number of non-indigenous people that consumed insects as indicated by 45% of focus group discussants (Section 5.4.5). Therefore, insect consumption can be considered as contributing to increased food security especially where other protein sources such as fish and meat were scarce. For example, discussant number 20 mentioned that edible insects were a source of joy for many people in this community because they were considered to be as good as meat and prevented people from starving whenever insects were available (Section 5.4.1).

Although insects in the Kaindu community were consumed for five reasons (nutrition, culture, taste, medicinal, and only food) the majority (74%) of householders consumed insects because of their nutritional value (Section 5.4.2), contrary to Manditsera *et al*. (2018) who found taste and culture to be major considerations for insect consumption. This shows that insects play a significant role in bridging the nutritional deficit in this community with consumers in this community eating insects twice a week (Section 5.4.2) when in season and handfuls of insects

per meal (Table 7). This may have positive nutritional benefits. For example, discussant number 24 (Section 5.4.3) mentioned that children who were fed on insect diets grew up healthy and were rarely sick as compared to people who ate fish and chicken.

However, the accuracy of measuring the contribution of edible insects to diets and nutrition of the consumers is problematic because there are no standard methods or mechanisms used to measure the calorific contribution to diets, compared to other commodities such as rice, wheat or maize whose precise measurements in terms of per capita consumption or global calorie supply are available (Van Huis *et al.,* 2022). This is because the growth of this sector (entomophagy) is still in its infancy, therefore, in this study, the contribution of edible insects is viewed from the perspective of frequency of consumption, average quantity of insects consumed per meal and also considering the known nutritional profiles of edible insects from the literature (Ghosh *et al.,* 2017). For example, 39% of consumers ate more than a handful (more than around 92 g) of insects per meal, meaning that the high protein and micronutrient content found in edible insects were possibly helping to combat nutrition deficiencies in this community. In addition, the calorific contribution of insects to a diet may be very different to the qualitative contribution to the diets experienced by consumers, which includes the extent to which insects provide a satisfactory and tasty meal. Therefore, calculating calorific values alone may not fully describe the motivations or preferences of consumers.

However, the extent to which edible insects contributed to household food security differed according to the motivation for consuming insects and the number of insects consumed per household. For example, despite this area having a variety of edible insects, most households consumed *Gonimbrasia belina* and *Gynanisa maja* caterpillars and *Macrotermes falciger* termites (Figure 15) while other species (*Cirina forda, Carebara vidua*, *Ruspolia nitidula* and *Ruspolia differens*) were neglected because they are considered as socially undesirable (Section 5.4.1). Insect consumption may also vary among people of different demographics and gender because of their preferences for specific types of insects. For example, in this community, male headed households consumed more insects than female headed households because females preferred eating caterpillars more than any type of insects while male households ate more of all the available types of edible insects (Section 5.4.1). Young and middle aged people (18–49 years old) consumed between 2 and 4 types of edible insects while those aged 50 years and above consumed 4 or 5 types of insects (Figure 17, section 5.4.2).

Utilization of edible insects varies within communities and can benefit people differently depending on their reasons for consumption and their preferences for certain insect types (Ghosh *et al.,* 2018). Discussant number 24 said that each insect type has a distinct and unique taste (Section 5.4.2.5). This means that consumers that did not like the taste of flying termites were not likely to eat them regardless of whether or not they are easily found in the local area. Additionally, preference for different preparation methods are also likely to influence insect consumption. For example, in this community, four different methods were used to prepare different types of edible insects (Section 5.4.6). However, 51% of respondents preferred insects to be fried which was argued to enhance the taste, whereas boiling was stated to improve insect palatability (Section 5.4.6). In addition, male consumers preferred fried and smoked insects while females preferred boiled and toasted insects (Section 5.4.6). This means that the different preparation methods could further influence variations of insect utilization between different demographics and genders. Additionally, the several different ways of insect preparation and methods of ingestion used in this community may require special culinary skills which often times are not recorded or transferred to younger generations as indicated by the area Councilor and discussant number 4 (Section 5.4.4). The concern is that the diminishing culinary skills among the young people may negatively affect the tradition or culture of eating insects.

However, it is known that preparation methods can enhance or reduce the nutritional value of certain insects (Meyer-Rochow *et al.,* 2021), therefore awareness of this issue may help communities chose the right method of cooking in order to acquire nutritional benefits from different type of edible insects. For example, 58% of respondents fried caterpillars while flying termites were mostly boiled (blanching) (Section 5.4.6). Frying caterpillars derives fewer nutritional benefits than boiling (Hlongwane *et al.,* 2022). To enhance effective utilization of edible insects in nutritional security, there is need to sensitize people on how different food preparation methods affected their nutritional profiles. Through sensitization, people would be able to make choices on how they would prefer insects to be prepared. For example, females may be more likely to benefit more from caterpillar consumption because their preferred cooking method is boiling (Section 5.4.6).

In this community, entomophagy was practiced as a matter of choice and part of a healthy dietary lifestyle (Section 5.4.3). This is contrary to the common belief that entomophagy was practiced as an emergency in times of food shortages or when other sources of protein were unavailable (Van Huis *et al.,* 2013). Insects were considered to be safer foods because they

were harvested from the wild where they feed on natural tree leaves and grass free of chemical contamination (Section 5.4.3). Discussant number 7 mentioned that this was a reason why people consumed insects out of preference (Section 5.4.3). It shows that people in this community were cautious of their diets and insects were consumed in part for dietary reasons. However, this viewpoint is not always correct and in Zambia at national level there are efforts to promote the consumption of foods that are not highly processed. For example, the National Food and Nutrition Commission noted that in recent years, Zambia has recorded an increase in nutrition related diseases such as obesity, heart disease and some forms of cancer, attributed to a nutritional transition from predominantly unprocessed traditional foods to ultra-processed foods high in fats, sugar and salt. To reduce nutrition related disease burden, the Commission encourages households to consume more of traditional foods which include edible insects (www.nfnc.org.zm). Thus, the consumption of edible insects may be used as a strategy to fight nutrition related diseases.

However, despite entomophagy being widely practiced, its potential as source of sustainable food, protein, valuable amounts of fats, minerals and vitamins (Ghosh *et al.,* 2017; Meyer-Rochow *et al.,* 2021), is hampered by the limited range of insect species that were consumed in this community. For example, only four types of edible insects (Section 5.4.1) were consumed despite Zambia in general having 50–100 species of edible insects available (Jongema, 2014; MLNREP, 2015). Therefore, entomophagy in Zambia remains underexploited as compared to other countries such as Brazil (Omuse *et al.,* 2023), China (Feng *et al.,* 2019), DRC (Bomolo *et al.,* 2017) and Thailand (Yen, 2015). For example, despite edible species such as *Brevisana brevis* (Hemiptera: Cicadidae) commonly known as cicadas and *Acheta domisticus* (Orthopera: Gryllidae) commonly known as crickets being found in this community, and people expressing knowledge that they were edible, these were not eaten by the local people because they were considered as socially unacceptable (Section 5.4.1). Similar to Stull *et al.* (2018), this finding shows that some edible insects are consumed based on their social acceptability and not necessary their nutritional value. Nonetheless, this study showed that the three main insects eaten (*Macrotermes falciger* and *Carebara vidua* termites, *Ruspolia nitidula* and *Ruspolia differens* grasshoppers and *Cirina forda* caterpillars) were collected from the local area, meaning there were minimal transport costs incurred and that the insects could be collected by all community members for free. Additionally, some preparation methods meant that insect dishes were cheap as no additional ingredients were required. For example,

Macrotermes falciger termites were fried or toasted in their own fat without adding cooking oil or tomatoes (Figure 21).

However, despite entomophagy being widely accepted in the community, there was still need to find innovative ways of broadening its acceptability among different demographics and cultural backgrounds. One challenge is the physical appearance of some insects which causes disgust among young people (Section 5.4.2.5). This could be addressed by chopping up or grinding the dry insect into other foods. This has been done elsewhere to add insects to other common food products such as wheat flour (Pambo *et al.,* 2018), rice noodles (Maw *et al.,* 2022) and porridge (Kinyuru *et al.,* 2012; Mmari *et al.,* 2015) especially for children. For example, caterpillars can be pounded into powder and incorporated in children's porridge to enrich its nutrition value and also to improve digestibility as mentioned by discussant number 14 (Section 5.4.6). It would not be strange to this community to introduce similar methods targeting other groups other than children.

Like any other food product, insects may be contaminated with foreign materials that may reduce the quality and safety of the whole insect. For example, grass, leaves and sandy particles were sometimes collected together with insects (Section 5.5.2) or where *Gonimbrasia belina* and *Gynanisa maja* caterpillars were not washed before blanching or toasting them in hot ash (Figure 32). This means that there is need for proper collection, sorting and washing to remove physical contaminants. Safety assurance may be the basis for developing standards that may help to allay fears of contamination and may also be required before any commercialization of insect products (Slingenbergh *et al.,* 2004; Tang, 2019). To improve the quality of insects and prevent them from going bad, as indicated by discussant number 13 (Section 5.4.6), there is also need to ensure that insects are dried fully. For example, if caterpillars are partially boiled and sun-dried or toasted in hot ash, they may be vulnerable to molds if moisture is not fully removed, and may compromise the quality or shelf life of the product. This can be done more effectively by using drying techniques or technologies used for other edible fresh products such as in onion preservation or drying of sardines commonly known as 'kapenta' in Zambia.

6.3 Factors influencing the practice of entomophagy in the Kaindu community

6.3.1 The effects of religion and traditional beliefs on consumption of edible insects

In this community, there are different consumption patterns among people of different religious denominations (Section 5.4.2.4). For example, Seventh Day Adventists are forbidden from

consuming insects, and 67% of the Adventists that did not consume insects cited religious beliefs whereas none of the Catholics, Jehovah's Witnesses and those that followed African traditions that did not consume insects cited religion as the reason (Section 5.4.2.4). This means that any restrictions or taboos that surround entomophagy among religious groups was likely to make people from different religious background treat and perceive edible insects differently. The fact that there were varying perceptions about edible insects among different Christian denominations shows that religion has some role in influencing how insects are utilized, depending on how individuals interpret religious beliefs regarding food. Owing to the fact that the majority (73%) of the population in this community follow the Catholic church, which does not forbid insect consumption, most people who consume insects are Catholics. In addition, Christians who consumed insects did not restrict themselves to *Schistocerca gregaria* (locusts) or *Acridoidea* Macleay 1821 (grasshoppers) and honey as mentioned in the bible but also consumed other types of insects such as *Gonimbrasia belina* and *Gynanisa maja* caterpillars and *Macrotermes falciger* and *Carebera vidua* termites. Since Christianity is the dominant religion in this community (Section 5.2.1.6) and across Zambia as a whole, it is likely that entomophagy would be practiced across many communities. These findings are similar to previous studies of how religious beliefs may influence the consumption of insects in communities (Ghosh *et al.,* 2018; Hlongwane *et al.,* 2020). However, the influence of religion on entomophagy in communities where there are different religious groups such as Islam and Judaism is not fully understood because in this study there were no participants from these groups.

Similar to Van Huis (2003), Ayieko and Ariero (2008) and Meyer-Rochow (2009), the findings of this study show that there were also prohibitory rules concerning the consumption of insects among different ethnic groups (Section 5.4.2.6). Food taboos and stereotypes exist in all cultures and in response to traditional knowledge of about edible insects. For example, ethnic groupings from certain traditional or cultural backgrounds where some insects are not eaten or where entomophagy in general was not practiced may consider insect consumption as a taboo, as indicated by discussant number 8 (Section 5.4.2.6). For example, it was not culturally acceptable among Lozi speaking people to consume any type of insects because entomophagy is considered demeaning. Thus, consumption patterns may vary among ethnic groups that live even in the same area. Food stereotypes may further be exacerbated by lack of tolerance or appreciation for other cultural viewpoints due to historical feelings of superiority or antagonism by some ethnic groups. For example, discussant number 8, who comes from the Lozi ethnic

group (a dominant ethnic group in western Zambia) mentioned that his people did not consume any type of insects because it was perceived as a practice done in tribes considered to be inferior to the Lozi (Section 5.4.2.6). This shows that ethnic supremacy may play a part in influencing insect consumption among different ethnic groups. Additionally, traditional ecological knowledge about where or when insects are found may also influence whether insects are utilized in certain geographical regions (Ramos-Elorduy, 2009; Müller, 2019). For example, in this community Lozi people did not have cultural knowledge of insects that are found in forests, because the Western province where they originate from is mostly comprised of plains and aquatic ecosystems that may not support the existence of caterpillars and other insect species found in drylands. This shows that familiarity with the landscapes and ecosystems in which certain insects are found is a precondition for the development of cultural knowledge about these insects as well as developing traditions regarding insect preparation and consumption.

Apart from traditional ecological knowledge, entomophagy is also influenced by the cultural and historical background of a community, as indicated by discussant number 15 (Section 5.4.2.6). Entomophagy was considered as part of the traditional food culture and as a way of showing cultural identity especially among Kaonde speaking people. This means that entomophagy is embedded in cultural beliefs and practices and as an expression of cultural pride and identity. For example, the area Councilor (Section 5.4.2.6) mentioned that certain insects were consumed by specific tribes in the community, subsequently causing differences in insect consumption from one household to another. This may mean that social classification of insects may cause stigmatization and possibly exacerbate any existing food stereotypes and taboos about entomophagy.

6.3.2 *Generational knowledge*

In this community, variations in consumption patterns among people of different age groups were noted. Older people consumed more and different types of insects than young people (Figure 17). This may indicate that there was a gap in traditional knowledge of edible insects between the older and younger people, hence causing variations in the number and type of insects consumed between different age groups. This could be attributed to different or parallel food cultures between the generations, including entomophagy (Section 5.4.4). For example, discussant number 2 mentioned that it was not part of young people's culture to consume insects despite acknowledging that insects were nutritionally valuable (Section 5.4.2.1). This

may indicate that different food cultures may exist in this community between young and old people, and entomophagy was one of them.

These different and emerging food cultures may result from general cultural changes associated with modernization and globalization in which young people perceive entomophagy as a primitive practice (Müller, 2019). This may mean that the community loses traditional knowledge of entomophagy, culinary skills and other traditional uses for insects are not transferred to younger generations by the older generation. For example, it was reported by discussants number 3 and 4 (Section 5.4.4) that young people in this community were spending less time learning about traditional and cultural practices. This includes folk stories and traditional ceremonies. Older people also consume 4 to 5 different types of insects while young people consume 2 to 3 types (Figure 17). This may show that there is already a decline in entomophagy and therefore food cultures. This points to the need for a revival of cultural platforms that can help facilitate transfer of traditional knowledge and to close gaps in generational knowledge. Additionally, the fact that young people were reluctant to consume insects might be interpreted as them being less attached to their culture and traditions, as indicated by the area Councilor and discussant number 15 (Section 5.4.2.6). A general disregard for edible insects amongst young or educated people has been noted previously in Botswana (Obopile and Seeletso, 2013) and Zimbabwe (Dube *et al.*, 2013; Manditsera *et al.*, 2018).

Other than the influence of modernization, the process of collecting certain type of edible insects also contributed to variations in the utilization of insects between older and younger people in this community. For example, some young people did not want to collect *Gonimbrasia belina* and *Gynanisa maja* caterpillars because it requires more time and the degutting process is considered laborious and dirty. The majority (62%) of *Gonimbrasia belina* and *Gynanisa maja* caterpillar collectors were older people while younger people were the main collectors of *Macrotermes falciger* and *Carebara vidua* termites, *Ruspolia nitidula and Ruspolia differens* grasshoppers (Section 5.5.2). *Macrotermes falciger* and *Carebara vidua* termites were more popular among younger people, possibly because they were collected from within the community and so there was less time and effort spent to collect them as compared to *Gonimbrasia belina* and *Gynanisa maja* caterpillars that were mostly collected from a greater distance away and require more strenuous processes (Table 9, Section 5.2.2). Insect collection processes that include fun activities could also contribute to how people in the

community engage with different types of insects. For example, younger people are the majority collectors of *Macrotermes falciger* (Section 5.5.1) and this may in part be attributed to the fact that these termites were mostly collected after midnight by firelight by young people amid fun activities such as role-play and storytelling. Additionally, the desire to try out new or unfamiliar foods may motivate some people to consume insects as was the case currently in the West were insects are consumed as novelty foods in specialized restaurants (Melgar-Lalanne, *et al.*, 2019; Lange and Nakamura, 2021).

It was also noted that some insect species such as *Gonimbrasia belina* and *Gynanisa maja* caterpillars were collected from bushes which were not safe or easy to access or navigate through (Section 5.5.2). This may discourage some people who may not have the ability to reach such places and may mean that some insects may only be collected by certain groups. For example, *Cirina forda* caterpillars locally known as Mishyankonko were mostly collected and eaten by older people because these are found within the Kaindu community (Figures 23). This may indicate that any gaps in traditional knowledge between different age groups may perpetuate stereotypes, perceptions and attitudes that may affect the utilization of certain types of insects by different demographics.

6.3.4 *Socioeconomic issues*

Education status was among the factors that influenced the consumption of insects in this community (Section 5.4.2.4). Contrary to Egan (2013) who found less consumption of insects among households with higher education status, in this community household heads who had achieved tertiary education consumed more insects than any other group (81%) while those with secondary education consumed least insects (Figure 18). This is contrary to the belief that entomophagy is practiced by 'primitive' people (Looy *et al.*, 2014). The majority (59%) of insect consumers in the tertiary education category cited nutrition as the main reason for consumption, while for those that attained secondary education level the most common reason for consumption (38%) was for cultural reasons (Section 5.4.2.2). This may indicate changing perceptions and attitudes concerning edible insects in developing countries based on knowledge rather than tradition. Educated opinion-leaders in communities with otherwise low literacy levels may help to communicate or frame information about the importance of entomophagy to other community members.

Taking into account that most people in this community (76%) had only achieved primary education, it was expected that education would play a role in changing people's perceptions and promote entomophagy across all education categories. Additionally, issues of sustainable harvesting, semi-domestication, insect farming and insect preparation methods may require education in an effort to preserve cultural traditional knowledge in communities where entomophagy is accepted as part of the normal food culture. However, younger educated people expressed aversions about entomophagy, as indicated by 40% of these respondents that participated in the focus groups (Section 5.4.2.5). This finding is contrary to Mancini *et al.* (2019) who found that educated young Europeans were willing to consume insects, possibly because they are seen as exotic rather than as part of indigenous food systems. This shows that attitudes other than knowledge or tradition play an important role in influencing food choices. The low consumption of edible insects among younger educated people in this community confirms that insect-based diets are perceived as different from current food traditions of modern societies (Sections 5.4.2.1, 5.4.4).

Low consumption of edible insects among young educated people may be influenced by certain perceptions such as fear, feelings of disgust and stereotypes and the need to align oneself to what may be considered as modern and superior food cultures (Sections 5.4.2.1, 5.4.4). These people may choose to show their modernity through the choice of foods they consume. Thus, western or European food cultures may have an unintentional negative influence on entomophagy in developing countries (Looy *et al.*, 2013; Van Huis and Vantomme, 2014). To mitigate the negative effects of appearance on the acceptance of edible insects, it may be important to incorporate edible insects into other food products such as biscuits, as has been done in Italy (Sogari *et al.*, 2019), flour in Kenya (Pambo *et al.*, 2018) and noodles in Thailand (Maw *et al.*, 2022). However, this strategy may be costly in rural communities without the financial capacity to process insects into other products, especially where most people in rural communities consume insects in simple fried or boiled forms.

Another factor influencing the consumption of edible insects in this community is income because there are some variations in consumption patterns between low- and high-income earners, similar to Egan (2013). However, in this community, high income earners consumed more insects than low income earners (Section 5.4.2.3). For example, 75% of high-income earners (above K20 000) consume insects while only 65% of the low-income earners (K987–K5000) do so (Table 8). Additionally, 26% of low-income earners consumed insects only

occasionally whereas 42% of high-income earners consumed insects twice a week (Section 5.4.2.3). Similar to Müller (2019) who found that wealthy people in Thailand and Laos consumed more insects than poor people, these findings show that the perceptions that entomophagy was closely associated with poverty or only as a last resort in times of hunger (Costa-Neto, 2016) could be wrong. For example, accessibility and availability are cited as the leading factors that determine insect consumption among all income groups in this community (Section 5.4.2.3). This means that high-income earners were more likely to consume insects, and low-income ones were likely to be more affected by food insecurity related to their economic status as well as their relative inaccessibility to edible insect resources.

Increasing physical accessibility to insect source areas may not be enough to enhance entomophagy because, currently, edible insects were scarce at the community level due to ecological change (Section 5.6.3). This means that for insects to sustainably contribute to diets for people of different income levels, they must be affordable or easily available in the wild even to lower income earners or for people with low mobility. Additionally, the prices of edible insects in this community were likely to be high and impact entomophagy negatively especially that insects are collected from the wild, which requires time and labour, factors that are known to have a bearing on the retail price (Ghosh *et al.,* 2017).

In this community, even though both male- and female-headed households consume insects, there are gendered variations in the types of insects utilized (Section 5.4.2.1). For example, females ate more *Gonimbrasia belina* and *Gynanisa maja* caterpillars than any other insects while men consumed more of all available types. This indicates that females are more selective and thus may become disadvantaged where they would not consume other types of insects even if they are available.

6.3.5 *Acculturation and socialization*

Despite modernization having some impact on the culture of entomophagy in this community (Section 5.4.4), the practice was increasing as mentioned by 45% of focus group discussants (Section 5.4.5). This means that entomophagy was widely accepted in this community as part of the food culture, including in those households whose ethnic background did not permit consumption of edible insects. For example, 31% of the people who consume insects did not have a history of entomophagy and insect consumption was not part of their culture (Section 5.4.5). Focus group discussant number 2 (Section 5.4.5) indicated that he knew of people who

initially did not consume insects but upon interacting with and being exposed to the local culture, they started consuming insects. Similar to Müller (2019), the practice of entomophagy was spreading to social and ethnic groups that previously did not eat insects. This can take place in particular where individuals or families move from one place to another in search of opportunities, meaning that people are likely to adopt the food cultures of their new communities.

Although modernity and new food cultures can impact the practice of entomophagy, especially among younger people in the community (Section 5.4.4), its erosive influence on entomophagy was minimal as the number of people that consumed insects overall still remained relatively high. It may also be that indigenous communities with strong cultural attachments are less likely to lose their cultural heritage and expressions in form of food, here from the dominant Kaonde ethnic group. Since it was a normal part of the Kaonde food culture to consume insects, other non-indigenous tribes such as the Lozi could be introduced to and adopt entomophagy, as indicated by discussant number 6 (Section 5.4.2.6). This shows that acculturation can help entomophagy gain ground and increase in this community. It also shows that cultural awareness about edible insects may influence the acceptability of entomophagy. For example, 14% of householders practiced entomophagy as part of culture and heritage (Section 5.4.2). Similarly, individual families may also promote entomophagy among younger people in this community. For example, 62% of insect consumers learnt about insects from their families (Section 5.4.5), and are likely to maintain this habit even outside their original cultural environment. This means that enculturation including learning early in childhood may influence one's food choices in later life (Nicklaus, 2016).

Similar to Nicklaus (2016), the findings of this study show that family or parental influence on food choices becomes a source of knowledge for young people (Section 5.4.5). People who learn early about food choices are likely to experience less cultural erosion where traditional knowledge is passed to younger generations through family and societal influences (Sections 5.4.2.6, 5.4.5). Other than family, socialization was also important. For example, 20% of insect consumers that did not have a prior history of entomophagy indicated that they learnt about edible insects through social interactions (Section 5.4.5). It shows that the social environment in which people interact may also be important in shaping people's interpretation and acceptance of insects as food, thus that knowledge, attitudes and beliefs about edible insects may be socially constructed.

6.4 Poverty reduction

In this community, the modal income (39%) of households was about K5000 ($188) annually (Section 5.2.1.4) which corresponds to an average monthly income of K420 ($15), which is half of the national monthly household income of K800 ($30) for rural areas in Zambia (CS0, 2010). This means that this community is poorer than many other communities in the country, affecting basic services, quality of life and a relatively high proportion of available income spent on food. Here, 71% of households spent their income on the purchase of food while 29% spent on both food and other groceries (Section 5.3.4), meaning there is limited money to invest in other areas that may yield alternative household incomes. For example, 47% of the households that did not keep livestock cited a lack of capital as the main reason (Section 5.2.1.5). This means that poverty is likely to perpetuate if people are unable to find extra money to invest in more resilient and sustainable livelihoods including agriculture implements or inputs to help increase agriculture production (Table 4). Poverty was also likely to worsen food insecurity in this area due to increasing food prices across the country. For example, the annual inflation rate for Zambia increased to 13.5% in February 2024 from 9.6% in the same month the previous year due to price increases for both food and non-food products (www.zamstats.gov.zm).

To reduce poverty in this community, there is a need to diversify income streams that may help rural households generate sustainable incomes that are more climate-resilient (IFAD, 2019). For example, 48% of focus group discussants (Section 5.6.2) indicated that householders were increasingly paying less attention to agriculture because they realized little economic benefits. Discussant number 2 (Section 5.6.2) mentioned that income generated from the sale of *Gonimbrasia belina* and *Gynanisa maja* caterpillars was higher and enabled insect traders generating income and restore their societal dignity. Edible insects were an alternative source of livelihood for 26% of households, and fishing for 14% of households (Section 5.2.1.5). This shows that wild resources, particularly edible insects, can be an important economic source. Based on the modal income of insect traders relative to average household monthly expenditure on food, the income generated from the sale of edible insects could possibly contribute about five months of the food budget. It was reported that some families who were previously poor were now managing to have three meals a day and their children going back to school after they started collecting and selling edible insects (Section 5.6.2).

Contrary to Hlongwane *et al.* (2021) who stated that the insect trade was based on traditional practice and indigenous knowledge, this study shows that insect trading had opened up business opportunities for people of different cultures and across society. For example, most of the people that participated in insect trade did not come from this community but from urban areas, involving wholesalers, retailers and transporters (Section 5.6.3). However, local people felt that they did not benefit much from the insect trade as they were reportedly marginalized because local people were unable to sale their insects locally or in urban areas because traders from cities monopolized and dominated insect trade as indicated by discussant number 3 (Section 5.6.3). This means that formalization of trade in insect resources across the value chain is needed in order to exploit these resources more effectively (Yen, 2015). This is because insect trading has been largely informal and undertaken at the local, community level. Under these circumstances, collectors in rural communities may be vulnerable to exploitation because they may not have accurate information on the market prices of insects but merely rely on the offers given to them by wholesalers. Lack of standardized prices and units of measurement for insects sold in traditional markets may further promote exploitation of both the trader and the buyer as there was no accurate way of determining the weights or the right price. Additionally, the price and quantity of insects sold depend on how much the consumer is willing to pay as prices are often negotiated rather than fixed. It may mean that informal collectors and traders at the community level may be leveraged out of the market by more effective business operations, increasing inequality and over-exploitation of natural wild resources. Formalization of the insect trade may help facilitate the integration of insects into mainstream economic frameworks as well as promoting innovation through improved storage, packaging and processing of insect products in different forms. Formalization of insect trade may also help to put up infrastructure that would enable insect availability at different periods of the year. For example, most insect traders sold their insects during the off season (Section 5.6.1) meaning that they needed to have the necessary infrastructure to preserve and store insect products.

Similar to Odongo *et al*. (2018), this study established that the insect sector in Zambia has been largely neglected, in part due to lack of policy recognition of insects as an economic or environmental common good. For example, Zambia's Second National Biodiversity Strategy and Action Plan 9 (NBSAP-2) for 2015–25 only refers to insects in terms of ecosystem services rather than their economic or nutritional importance. Additionally, the Eighth National Development Plan (8NDP) which is Zambia's strategic plan for transforming the country's economy, inclusiveness and sustainable development by 2030 only recognizes the management

of water and water resources for socioeconomic development. Insect resources are not mentioned.

The problem concerning the non-recognition of edible insects as an economic good is something that is missed from the Millennium Ecosystems Assessment framework (MEA, 2003). This is because different economic sectors such as the pharmaceutical and feed industries can also make use of insect resources in different ways. For example, only two types of common insect species *Gonimbrasia belina* and *Gynanisa maja* (caterpillars) and *Macrotermes falciger* (termites) currently seem to have commercial value in Zambia as they are the ones that are widely sold (Section 5.6.1) despite there being other insects such as crickets, and cicadas that could possibly be used in other sectors such as poultry as food. However, there may be a need to remove barriers such as difficulties in accessing harvest sites or the limited quantities of insects that are harvested from the wild, which 41% of respondents indicated as a limiting factor (Section 5.6.1). Without increasing insect volumes through technological innovations, insect trade may still remain marginalized. This can be addressed through the establishment of insect farms. Insect farming may not be alien to the Kaindu community and Zambia as a whole because some people are engaged in apiculture (bee-keeping) as a source of livelihood (Mickels-Kokwe, 2006). Other insect types could also be farmed commercially and used to boost entrepreneurial activities, but this may require loans or grants as starter capital. Insects may also have potential value in the pharmaceutical sector as indicated by 3% of respondents (Section 5.4.2) and by the area Councilor (Section 5.4.3), but this may require legal agreements between insect farmers and traditional (tribal) leaders and pharmaceutical companies. Recently in Africa, there has been an increase in the number of registered new private enterprises to start farming insects (Tanga and Kababu, 2023). The surge in the number of insect farms or insect related enterprises on the African continent may help to alleviate poverty especially among vulnerable groups such as the youth and women.

However, to reduce poverty in rural areas, a broader range of nature-based resources including insects could be exploited. However, like any other economic resource, an increased market demand for insects particularly *Gonimbrasia belina* and *Gynanisa maja* caterpillars may cause over-exploitation and inequalities in access. For example, 22% of respondents attributed the scarcity of edible insects to over-exploitation (Section 5.7.2). Discussants 1 and 11 (Section 5.6.3) mentioned that it was difficult for some people to benefit from insect resources when local insect collectors prefer selling to traders from urban areas who were their permanent

clients. As such, the local community was being marginalized. Regulatory mechanisms are therefore needed to ensure sustainable and equitable use of ecological resources through formulation of policies that integrate social, environmental and economic considerations.

6.5 Emerging trends in insect utilization

6.5.1 Demand for edible insects in urban areas

This study shows that entomophagy is not restricted only to the Kaindu community but that there are significant links to urban markets (Section 5.6.3). For example, all the 36 respondents that collected edible insects for sale sold their insects in urban areas with the majority (53%) taking their insects to Lusaka (Section 5.6.3). This shows the spatial extent and complexity of trade networks that must now be considered in terms of insect supply and demand. For example, despite the Kaindu community being located in the peri-urban areas of Mumbwa district and where some of the edible insects were collected from, none of the traders sold their insects within the community. Most (53%) of the traders supplied insects to Lusaka city, 33% to Mumbwa town and 14% to Copperbelt Province (Section 5.6.3). Similar to Yen (2015) and Müller (2019), these findings indicate that urban areas are now emerging as the major markets for edible insects, rather than rural areas.

As a result of the increasing demand for edible insects in urban areas, *Gonimbrasia belina* caterpillars are now being sold in urban chain stores (Figure 28). This means that entomophagy can be considered as a suite of food sources contributing to food security in urban households. With this commercial part of insect foods in the value chain, it is likely that this corresponds to improvements in quality and food safety. The inclusion of other common insects in these urban stores may also help to widen consumer access to insects and diversify food sources, as well as drive the supply end of insect systems in rural areas. Better road access to harvest sites may improve accessibility and reduce transport costs.

Similar to Lange and Nakamura (2021), this study shows that despite entomophagy being widely accepted in the Kaindu community, local people were getting little benefits from insect resources because of their scarcity and increasing demand in urban areas. This means that poor rural households may not experience an increase in food security if they are not able to access and afford to buy insects at the same market price as in urban areas. Further, 14% of respondents indicated that they felt that outsiders (traders from urban areas) were benefiting most from insect resources (Section 5.6.3). To manage this imbalance, there may be need to

increase insect populations in rural communities through establishing insect farms (Gahukar, 2016) or improving wild populations through good environmental practices (Cardoso *et al.*, 2020).

6.5.2 *Ecosystem disruption*

In the Kaindu community, populations of different types of insects have been in decline (Section 5.7.1) due to environmental pressure (Sintayehu, 2018) and anthropogenic activities (Müller, 2019; Wegnar *et al.*, 2021). Certain habitats for termites and caterpillars have been encroached and in some cases destroyed by the use of insecticides and pesticides or deforestation which affects insect life cycles (Section 5.7.2.1, Figure 30). This shows that the state of ecosystems likely determines the availability of edible insects in a given locality, thus a reduction in insect populations likely reflects the state of ecosystems in this community. Since insects form part of the diet for the majority of households, the state of ecosystems can be considered as a determining factor in food security. For example, it was reported that previously a variety of insects were found locally and in abundance (Section 5.7.2.1), but now environmental degradation was reducing insect availability, food security and sustainability among rural households. Expanding agricultural fields highlights a dichotomy between the need to improve food security through increased agricultural production, and the need to protect the environment, biodiversity and ecosystem services. For example, anthills are being destroyed and removed from agricultural fields but these are habitats for termites. This is different to the findings of Payne and Itterbeeck (2017) who reported efforts in some communities of Mexico, Burkina Faso, and Zimbabwe to conserve insect habitats within agricultural fields.

The spread of agriculture and settlements into previously unoccupied and ecologically sensitive areas such as the Kafue plains (a Ramsar site), forests and the Kafue river as reported by the area Councilor (Section 5.7.2.1) may cause distortions in insect populations and distribution and local extinction as a result of ecological disturbance. For example, people in this community previously used to collect different types of insects from their backyards or within local bushes which made it easy for many people to consume insects, however this is now no longer the case as reported by discussant number 25 (Section 5.2.2.1). This suggests that the declining insect population especially of those that are socially and economically important such as caterpillars was affecting the practice of entomophagy.

In the Kaindu community, changing landscapes (Musakwa, 2020), expanding agricultural land and the use of pesticides (Müller, 2019; Wagner *et al.*, 2021) were responsible for declining insect populations. For example, the bee population in this community had drastically reduced and caused a decrease in honey production, as reported by the area Councilor (Section 5.7.2.1). The absence of bees as pollinators may further negatively affect ecosystems and agriculture. However, the rejection of certain species of edible insects by some consumers would arguably reduce the pressure on the resource, therefore contributing to ecological sustainability (Ghosh *et al.,* 2018). Nevertheless, this idea is debatable as the rejection of some insect species may not be informed or motivated by the desire to safeguard ecosystems or the availability of the insects concerned but other factors.

The destruction of forest and other ecosystems in the Kaindu community was done despite the local people demonstrating knowledge of the importance of ecosystems for the sustainability of food systems and different insect species. For example, discussant number 25 and the area Councilor mentioned that edible insects had become scarce because there was the cutting down of trees, especially those hosting caterpillars (Section 5.7.2.1). Additionally, because of the scarcity of edible insects, there was the possibility that the reduction in poaching and illegal fishing recorded in recent years (DPNW, 2013) was likely to be reversed because people would not have alternative sources of food and livelihood. Furthermore, scarcity of insects may affect the food chains of wild birds whose source of food are insects. This means that disruption of habitats could lead to other ecological problems that have wider ecosystem service and biodiversity implications (Cardoso *et al.,* 2020).

In the Kaindu community, people understood the importance of maintaining healthy ecosystems and trees to promote and sustain the presence of insects as indicated by discussant number 4 (Section 5.5.2) and discussant number 6 (Section 5.7.2.1). For example, people mentioned that despite seeing the presence of butterflies in the community, *Gonimbrasia belina* and *Gynanisa maja* caterpillars were still not available because host trees were destroyed by those that produced charcoal, as reported by discussant number 13 (Section 5.7.2.1). Indiscriminate bush burning was also linked to the scarcity of grasshoppers, as mentioned by discussant number 7 (Section 5.7.2.1). A significant minority (34%) (Section 5.7.2.1) of respondents felt that there was need to protect habitats such as forests and specific host trees to preserve nature and edible insects. This shows that there was willingness from community members to protect ecosystems especially that the community with the help of a local non-

governmental organization (COMACO) was willingly participating in reserving some land for tree regeneration or reforestation as indicated by the area Councilor (Section 5.7.2.1). However, this requires different stakeholders to identify priority areas and to use culturally appropriate conservation methods. For example, discussant number 21 (Section 5.5.2) said that when caterpillars (*Gonimbrasia belina* and *Gynanisa maja*) achieve the right developmental stage they come down from the trees and can be collected (Figures 24, 25). This can be considered as an indigenous conservation method to sustainably harvest insects. However, despite such community knowledge, there is a general lack of environmental stewardship by the local or planning authorities to promote resilience and conservation of various ecosystems that host different edible insect species (Section 5.7.4). Contrary to Mbata *et al.* (2002) who observed that there were traditional mechanisms put in place to regulate the harvest of caterpillars in the Kopa chiefdom, such mechanisms were absent in this community. This speaks to the wider need for environmental and resource management and conservation methods at the community level to enhance environmental sustainability.

6.5.3 *Climate variability*

Climate change and extreme weather events are known to have negative impacts on agriculture and food security (Nyangena *et al.,* 2020). Like many other agrarian communities, the Kaindu community is vulnerable to the effects of climate change because 50% of respondents are dependent on agriculture for their livelihoods (Section 5.2.1.3). For example, 31% of focus group discussants had noted a delay in the onset of the rainy season from October to December (Section 5.7.2.2). Taking into account that the Kaindu community has an agrarian economy, climate change and extreme weather events are likely to have significant negative effects on agriculture production and food security (WFP, 2022; UN, 2023). For example, the shift in the onset of the rainy season means a shorter period of agricultural production and potentially reduced crop yields. In addition, temperatures in Zambia have increased by 1.3°C since 1960 at an annual average rate of 0.29°C per decade, and has been experiencing a decrease in annual rainfall of 1.9 mm per decade (USAID, 2016).

These changing conditions pose problems for both rain fed agricultural crops and natural ecosystems. Uncertainty surrounding rainfall patterns makes planning by farmers difficult in choosing the most suitable crops and seed varieties to withstand the prevailing conditions, and other water harvesting technologies such as irrigation and dams may have to be employed. However, this requires capital investment and upkeep. The general lack of spare capital and

uncertain agricultural extension services available in the Kaindu community may limit the ability of smallholder farmers to increase climate resilience through agriculture alone. Thus, conservation farming methods may be more sustainable and cost-effective as these may help with retention of soil moisture, ecosystem services, and maintain the environmental conditions under which insects can coexist (Prather and Laws, 2018).

Water scarcity is also likely to worsen food and nutrition insecurity and possibly affect dietary choices for households that depend on garden vegetables. For example, 78% of the food secure households were involved in gardening as alternative source of food. Additionally, water scarcity may increase the risk of ecological and ecosystem damage because of land use change (Section 5.7.2.1). For example, most wetlands were now being used as grazing areas for cattle and goats while traditional grassland grazing areas were now being used for settlements. This points to the potential of changing land uses which may worsen current ecological challenges.

Increased temperatures are associated with an increase in the developmental rate and geographical distribution of agricultural pests such as *Spodoptera frugiperda* Smith 1797 (fall army worms) (Yan *et al.*, 2022). For example, in the last 10 years, Zambia has experienced outbreaks of *Spodoptera frugiperda* in eight farming season affecting all the districts in the 10 provinces with an infestation rate of 22% or 157 941 hectares of maize fields per season (www.agriculture.gov.zm). Agricultural pest outbreaks may also lead to a reduction in social spending by government agencies where resources are diverted towards the purchase of chemicals. For example, in the 2023 farming season, government spent K50 million (USD 2.3 million) as emergency funds to purchase chemicals to control army worms that had infested crop fields across the country (www.znbc.co.zm). Biological controls on agricultural pests such as collecting army worms to feed to poultry is more economical and has lower environmental impacts.

Similar to Egan *et al*. (2015) who found that annual climatic fluctuations, particularly droughts or dry conditions resulted in the reduction of some insect species specifically *Hemijana variegate* Rothschild 1917 (caterpillar), this was also the reason attributed for changing insect patterns in the Kaindu community by 33% of respondents (Section 5.7.2.2). Discussant number 8 (Section 5.7.2.2) mentioned that prolonged dry spells or delay in the start of the rainy season were the causes of insect scarcity. For example, the rainy season used to start in October in this area and the first rains were associated with the presence of edible insects such as caterpillars,

flying termites and thief ants. This was locally referred to as 'imfula ya finkubala', meaning rains that brought caterpillars (Section 5.7.2.2). However, this is no longer the case as the presence of caterpillars has now been delayed until the month of December.

Although rainfall variability and higher temperatures are anticipated to negatively affect insects in Zambia (MLNERP, 2015), there is a general lack of practical strategies to promote resilience and conservation of different ecosystems and insects. Development of bee-keeping by small scale farmers spear headed by (COMACO) a local non-governmental organization is one such strategy (Section 5.7.2.1). At a national level there has been an increase in honey production from 300 tons in 1971 to 903.79 tons in 2022 (https://knoema.com/FAOPRDSC2020/production-statistics-crops-crops). Other edible insect species such as *Gonimbrasia belina* caterpillar (Ghaly, 2019) and *Ruspolia nitidula* grasshopper (Agea *et al.*, 2008) could also be farmed successfully if appropriate measures were put in place. The protection and sustainable management of edible insects in the wild may result in the protection of other fauna and flora within ecosystems. It may also lead to reduced use of pesticides in agricultural ecosystems where insects' population have decreased.

The findings of this study show that edible insects provide alternative sources of livelihoods and food security to the Kaindu community (Sections 5.2.1.3, 5.4.1). However, lack of a clear management framework and strategies towards environmental stewardship have affected the potential for edible insects to be sustainable food and economic resources. This means that there was need for an integrated management system that integrates ecological and socioeconomic systems towards sustainability of the environment, livelihoods and food security.

6.6 The traditional cultural contexts and uses of insects

In the Kaindu community, the use of insects was not only limited to food and livelihoods but also extended to the cultural and moral values considered to be in conformity with the traditional norms of the community (Section 5.4.7). For example, discussant number 13 (Section 5.4.7) mentioned that it was not allowed for people to engage in fights, sexual activities or even murders from the bushes where insects were found, as doing so would make insects disappear. It was also culturally prohibited for women who were menstruating to travel to the bush to collect insects as reported by discussant number 15 (Section 5.4.7).

In the Kaindu community, especially among the Kaonde speaking people, the presence of certain insects was understood to carry messages from the ancestors. For instance, discussant number 7 (Section 5.4.7) mention that when *Gonimbrasia belina* and *Gynanisa maja* caterpillars were in abundance in a particular season, they believed that in that year, there would be a lot of rain and enough food because ancestors were happy with the people, and as such, needed to be rewarded. On the other hand, when *Gonimbrasia belina* and *Gynanisa maja* caterpillars become scarce in a particular season, it was interpreted that there would be less rain and increased hunger because their ancestors were not happy and punishing them for not conforming to certain practices (Section 5.4.7). The use of insects to interpret nature means that the community would be in a position to adequately prepare and plan for the rainy season ahead especially in the absence of meteorological information. The community would also be in a position to adequately plan for prudent use of available food stocks especially maize to promote household food security in the event that there was an adverse traditional forecast. In the same vein, since the presence of some insect species such as *Macrotermes falciger* and *Carebara vidua* termites was associated with the amount of rainfall received as reported by discussant number 2 (Section 5.7.2.2) means that the presence or absence of these insects (*Macrotermes falciger* and *Carebara vidua*) at the beginning of the rainy season may help farmers to make decisions on when they needed to plant their crops.

There are certain cultural beliefs in the community that are concerned with protecting the environment or certain insect species from over-exploitation. For example, 24% (Section 5.4.7) of focus group respondents said that it was forbidden to harvest caterpillars without permission from the traditional leadership. Some insects were also used as medicines for certain ailments based on the application of traditional oral knowledge and informal healers or apothecaries within the community (Section 5.4.2) and also as mentioned by the area Councilor (Section 5.4.3). Different ethnic groups may have different knowledge, traditions and values for different types of insects, so changing community composition by migration and ongoing cultural creep may mean that these oral-based traditions and practices are now becoming marginalized or dying out. On the other hand, such traditions can be used to promote cultural and community identity as well as strategies for nature and ecological sustainability.

6.7 Conclusions and links to the Sustainable Development Goals

It was found in this study that edible insects are used as food, a source of livelihood and as a mechanism to promote cultural and traditional values at the community level (Sections 5.4.1,

5.4.7, 5.6.1). Although entomophagy was widely accepted and practiced in the community, variations were noted mainly due to ethnic background, the physical appearance of some insects, assumptions and stereotypes about particular foodstuffs, demographic factors, and religious beliefs (Sections 5.4.2, 5.4.4, 5.4.6). The study further showed that, contrary to the trend in some African communities, the erosive effects of modernity on entomophagy was minimal as the practice still remained high in this community because of acculturation and socialization trends (Sections 5.4.2.6, 5.4.5). Further, entomophagy was practiced as a matter of preference because edible insects were considered to be healthy, nutritious and cheap because they were harvested from the wild (Section 5.4.3).

The results suggest that insects can be used for a variety of purposes and to address a range of challenges affecting rural African communities, including food security, dietary diseases, environmental degradation and poverty. However, their utilization to address these issues has been very low due to lack of recognition of the importance of insects, and lack of adequate infrastructure and policies. With increasing research in the insect sector, it is likely that insect utilization will be applied more widely in agriculture and ecosystem rehabilitation to help improve food security and reduce the use of chemicals. It is also likely to be developed in the pharmaceutical industry (Meyer-Rochow, 2017) and the human food and animal feed industries (Van Huis, 2021).

Development and exploitation of insect resources at the community level can be applied to several of the United Nations Sustainable Development Goals (SDGs) which aim to achieve sustainable, balanced and prosperous futures for all global citizens. For example, 26% of respondents in this community depended on insects for their livelihood. In some cases, the income generated from the sale of insects was even higher than that from agricultural activities (Section 5.6.2). Thus, if effectively utilized, insects can help to achieve SDG 1 which aims at ending poverty. Entomophagy is part of normal food culture with 68% of respondents in this community consuming insects regularly. Additionally, because insects were considered nutritionally better than poultry, fish or beef, 74% of respondents were motivated to consume insects because of their nutritional value. These advantages address SDG 2 which aims at ending hunger, achieve food security and improve nutrition. A significant minority of respondents (34%) also considered entomophagy to help with dietary related diseases as they are considered to be organic and natural foods with positive health outcomes (Section 5.4.9). This applies to SDG 3 which aims at achieving good health and wellbeing. SDG 12 aims at

achieving sustainable consumption and production patterns (which includes ecological resources as well as industrial/manufacturing consumption and production). Here, insects are harvested from the wild using artisanal, low-intensity methods with a low environmental footprint and therefore can be considered as contributing to SDG 12. This study shows that environmental degradation resulting from expanding human settlements and agricultural land contributes to reducing insect populations (Section 5.7.2.1). Therefore, protecting the environment and insect habitats can support terrestrial ecosystem sustainability, which is the focus of SDG 15. Entomophagy can also help achieve SDG 16 which seeks to achieve peace and inclusive societies. For example, in this community, insects were used as a mechanism for promoting peace, harmony and unity among people of different ethnic backgrounds (Section 5.4.7). However, the role that insects may play in bringing together different aspects involving the environment, society and sustainability may depend on how insects are used and valued by different communities.

Chapter 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter summarizes the main findings of this study and recaps the lessons learnt from how people in the Kaindu community use and value edible insects. The three areas highlighted in this chapter are summaries of the main findings and their implications in line with the study aims, recommendations for different stakeholders, and areas of possible future research focusing on sustainable insect utilization.

7.2 Recapping of the findings

The aim of this study was to analyze and understand the degree of acceptability of edible insects and the extent to which they contributed to household food security and livelihoods to people in rural areas of Mumbwa district of Central province in Zambia. The research also identified the major factors that affect the sustainable utilization of edible insects including how these contribute to food security and livelihoods. In this community, edible insects play a significant role in bridging food and nutritional deficits. The majority of respondents ate insects as part of their normal food habit because insects are considered to be nutritionally valuable. Nutrition was the most common motivation to eat insects and the majority of the consumers ate insects twice a week. Further, consumers ate more than a handful of insects per meal. These quantities likely offer sufficient nutritional benefits to consumers, helping to improve diets and reduce undernourishment. This study established that insect consumption also takes place as a lifestyle choice to promote health diets. For example, some people preferred eating insects to other proteins because they are organic and harvested from the wild. This means that local indigenous diets, specifically entomophagy, could be used as a strategy to reduce the risks of diet related diseases such as obesity resulting from changing and westernized diets in urbanizing communities.

Other than food, this study established that some of the households depended on selling insects as an alternative source of livelihood and thus served as an economic safety net for rural communities. Contrary to the belief that local communities collect insects solely for domestic consumption, this study shows that insects were also collected for sale to both wholesalers and retailers in nearby urban areas. This was a planned and deliberate strategy as traders sold their insects at different periods of the year, either fresh and immediately after harvest, or stored and

sold later when there was an increase in price. However, a lack of formal markets and adequate storage and processing infrastructure hinders the potential of edible insects to be fully developed as alternative sources of income for rural communities.

In the Kaindu community, insects were not only consumed for physical survival but as a form of cultural identity and heritage. However, some young people were not willing to eat insects because they felt that it was not part of their food culture, disgusted and thought that entomophagy was not in conformity with modernity leading to variations in the consumption and type of insects consumed by different demographics. In part, this is related to the labor and time required to collect certain types of insects and the landscape where these are found. Additionally, insect consumers of different ages and genders have different insect preferences and use a range of preparation methods. Attitudes other than knowledge and tradition also play an important role in influencing food choices. This is because young educated people showed aversion to insect consumption because they were more interested in western food cultures.

In the Kaindu community, a majority of the respondents noted a decline in insect populations and this was attributed to environmental and human activities which were exerting pressure on ecosystems. Changing landscapes, habitat destruction, expanding agricultural land and deforestation are the major factors responsible for the declining insect population in general. There was also a shift in the onset of the rainy season from October to mid-December and prolonged dry spells, as reported by some focus group discussants. Edible insects had become scarce as a result. Thus, climate change and variability have disrupted agricultural livelihoods and food and nutrition security in this community. This study also showed that insect resources could play a vital role in achieving some of the Sustainable Development Goals, in particular through promoting the utilization of edible insects for sustainable ecosystems and livelihoods.

Edible insects were being utilized effectively to bridge food and nutritional insecurity problems among people in this community, however scarcity, lack of adequate insect quantities and limited number of edible insect species consumed in this community were hindering the potential of edible insect resources to be a sustainable source of food and protein. Other than food, entomophagy was used as a strategy to promote healthy lifestyle and reduce the risk of diet related diseases such as obesity resulting from changing diets such as the increase in the consumption of non-organic foods.

However, the practice of entomophagy was changing in this community due to several issues that included the effects of modernization, negative attitude by some young people and the destruction of ecosystems such as forests and grasslands for purposes of increasing agricultural production and human settlements. This points to the need for a comprehensive and integrated approach in managing complex systems in which humans interact with nature. In this case, since most households in this community relied on nature and the exploitation of biodiversity and ecosystem services for food security and livelihoods, there was need for transformative approaches to human–nature engagements in the wake of increasing hunger and poverty levels in Zambia, and the world at large particularly in rural communities of developing countries where people depend on extraction of ecosystem services for their livelihoods.

7.3 Recommendations to government and Non-Governmental Organizations

Based on the results (Chapter 5) and discussion of this study (Chapter 6), the following recommendations can be proposed to relevant stakeholders and decision-makers to enhance insect utilization and sustainability.

1. It is recommended that entomophagy should be taught in the formal education system to children in order to promote awareness about entomophagy especially in communities or regions where entomophagy is less common due to cultural barriers. This can be done in the context of classes in language, traditions and cultures, environmentalism, ecology, or climate change.
2. Since this study has shown that wild populations of edible insects have declined due to anthropogenic and environmental factors, it is important for government departments and agencies including Non-Governmental Organizations (NGOs) working in the environment, food security and sustainability sectors to emphasise and explore the development of commercial insect farming, as has been done with bee-keeping. This may help ease the pressure on wild insect populations and promote food security and more climate-resilient and sustainable sources of alternative livelihoods other than agriculture.
3. Governments working with relevant NGOs should establish nutrition clubs in rural communities to teach people about different sources of food and nutrition, how to grow typical garden foods and rear small animals such as chickens, and how to cook. This may help to improve food and nutrition security because people would be aware about different forms of foods and their nutritional qualities. This can also be linked to promoting foods as an income source, through entrepreneurship, small grants, and mentoring.

4. Governments should collaborate with the private sector and Higher learning institutions to develop insect harvesting and storage technologies that will help increase the quantities of edible insects harvested from the wild and in a sustainable way. Innovative technologies to improve packing and storage of edible insects in different forms will also ensure maintain availability and the quality of edible insects all year round. This also needs to be done in combination with local insect collectors and community cultural and agricultural leaders.
5. Local traditional leadership(s) in different communities should work with other stakeholders and community members to formulate strategies for the promotion and preservation of traditional and cultural knowledge, including that of entomophagy, whose sustainability is challenged by socioeconomic and cultural change, including the influence of western diets and products.
6. Governments should establish data and information centers that would document trends in natural ecosystems, insect diversity and populations, and the insect trade in order to formulate policies and management strategies to safeguard the interests of different sectorial actors.
7. Governments should upgrade rural infrastructure such as road networks in order to ease the movement of people and goods. This may enable disadvantaged people to better access services such as schools and hospitals, and markets for products such as foodstuffs and edible insects. There is also a need to establish water facilities such as boreholes in the bushes where insect collectors set up camps when collecting insects in order to improve hygiene and food safety when processing edible insects. However, this should not be used as a basis for further settlement encroachment into these areas.
8. There is need for chain stores in urban areas to broaden the variety of edible insect species sold in order to cater for different needs and preferences for consumers, and to prevent over-consumption of certain insect types by promoting sustainability activities such as habitat conservation.
9. It is recommended that government and NGOs working in the food and nutrition security sector should embark on effective and creative advertising campaign by using appealing phrases, suitable ways of presentation and packaging to help change perceptions of consumers especially in communities where insects are shunned.

7.4 Future research focus

This study highlights a number of interconnections between food, sustainability, cultural practices, and rural socioeconomic development. Different future research topics can be identified that expand upon individual areas of concern. This can be done either in Zambia or in similar rural developing world settings elsewhere in Africa. Future research focus areas include:

1. Investigate the acceptability and the viability of farmed edible insects in rural communities, any associated technical challenges, ecological or pollution consequences, and infrastructure required.
2. Consider in more detail the impacts of climate change on specific insect species such as grasshoppers, flying termites and thief ants, in particular focusing on the ecosystems contexts and any climate-induced phenological changes that impact upon insect services, including the role of insects on urban food systems.
3. Assess the contribution of edible insects to food security and livelihoods in urban areas. This includes mapping insect species biodiversity and home ranges in urban settings.
4. Consider the cultural contexts of entomophagy, including how followers of other religious faiths such as Judaism and Islam perceive edible insects.
5. Analyse the potential impacts of chemical and pesticide use on levels of chemical contamination in edible insects, how they affect the life cycles of edible insects and any potential health or environmental effects.
6. Evaluate the extent to which declining insect population in agro-zones has contributed to food insecurity and ecosystem services in rural communities.
7. Investigate how different insect preparation methods influence the consumption of edible insects among people of different demographics, including their perceptions of food tastes, textures and nutrition levels.
8. Investigate which species of edible insect species had the high potential for allergens. This will ensure that consumers are well informed and protected from harmful reactions.
9. Assess how gender disparities affect household food security and livelihoods, in order to formulate strategies that would enhance inclusiveness and equity. This includes considering all types of food sources (agriculture, wild foods including insects, garden vegetables) and their roles in household-level food security and incomes.

10. Consider in detail how diversifying socioeconomic activity in the study area could be used as a strategy to reduce the increasing demand for natural resources and the consequent pressure on the physical environment.

7.5 Limitations

Questionnaires were distributed to the four administrative zones of the ward which are far away from each other. The distribution of questionnaires was time consuming especially that the researcher had to walk long distances to find homesteads. The sample size was calculated from the 2010 Census of population and housing and this may not necessarily reflect the present population patterns. Although the majority of participants that participated in the focus group discussions could understand what the discussion was all about, some discussants had difficulties in expressing themselves because of different dialects and low literacy levels, which meant that some discussions took more time than expected as the research assistant had to interpret some of the things in order for the participants to grasp what was needed. The ethnographic observations on insect collection in the Ngabwe district were limited due to logistical camping challenges, inaccessibility of some collection sites that were located in the interior, and safety in the bush which was not guaranteed.

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Appendices

Appendix 1: Questionnaire

Questionnaire

Participant Number: ……

Household socio-demographics. [Kindly tick in the box or answer verbally]

1. What is the age category of the head of this household

18 -24	
25-39	
40-49	
50-59	
Above 60	

Which gender is the head of this household……

How many people live in this household ……

How many are Male and Female

M	F

What is the age distribution of the members of this household

……

……

……

……

How many people go to school in this household?

……

……

……

……

How many people in this household have completed secondary education?. .....

……

What is the highest level of education for the head of this household?

……

……

Does this household follow any religious beliefs? Yes [ ] No [ ]

Explain……

……

……

……..

What is this household's main source of income?

……
……
……
……..……..

What range is the annual income for this household?

1000 -5000 (Kwacha)	
5000-10000	
10000-20000	
Above 20000	

Do people in this household engage in agriculture? Yes [ ] No [ ]
Explain……
……..……
……
…….

Does this household keep or rear animals? Yes [ ] No [ ] Explain

……
……
……
……..……..

Does this household have any other source of income Yes [ ] No [ ]
Explain……
……..……..……
……
……..……

<u>Household food security</u>

How much money in Kwacha does this household spend monthly on the purchase of food?
Explain……
……..……
……
…….

Where does this household mainly get its food from……
……
……
……..……..

What is the distance in kilometers to where you get your food from

……
……..…….

How many meals does this household have per day

……

……

What type of food (s) does this household mainly consume……..

……

List other alternative source (s) of food for this household

……

……

……

……..……..

Does this household run out of food at certain times and why Yes [ ] No [ ] explain

……

……

……

……..……..

Who are the most affected people in this household during times of food shortages

……

……

……

……..……..

What strategies or methods do you use to deal with food insecurity

……

……..……...……

……

……

Insects' consumption

Do members of your household consume edible insects?

Yes [ ] No [ ] Not all,

explain……

……

……

……..……

……

……..…….

Who eats insects in this household?

Young people [ ]

Elderly [ ]

Males [ ]

Females [ ]

Everyone [ ]

How often do insect consumers in this household consume insects?

Occasionally [ ]

Once a week [ ]

Twice a week [ ]

Monthly [ ]
Why do they consume insects?

Nutrition [ ]

Only food [ ]

Culture [ ]

Medicinal [ ]

How much insects does your household consume per meal?

Handful per meal [ ]

Less than handful per meal [ ]

More than handful per meal [ ]

How long have members of this household been eating insects
……
……..……..
How did you know about edible insects ……..……
……
…….
What is the history associated with edible insects in your household
……
……

……
……
Does your household achieve any positives from the consumption of insects? Yes [ ] No [
Explain……
……
……
……
What negatives are associated with insect's consumption?
Explain……
……
……
Insect's collection
Who collects insects in this household?

Young people [ ]

Elderly [ ]

Males [ ]

Females [ ]

Everyone [ ]

Where does this household collects its insect resources from?.....
.....
.....
Which insect type(s) are collected by this household? Why
……
……
……
Do you consume insects immediately after collection? Yes [ ] No [ ]
Explain……
……
……
How important are insect diets to this household?
Not important [ ]
Slightly important [ ]
Important [ ]
Very important [ ]
Explain……
……
……
……

How many insect types does this household consume……
……..

Are you aware of other insect types that you don't consume? Yes [ ] No [ ]
Explain……
……
……

What determines consumption of insects in this household?
Affordability [ ]
Accessibility [ ]
Culture [ ]
Availability [ ]
Explain……
……..……
……..……..
How do you prepare insects for eating?
Smoke [ ]
Boil [ ]
Fry [ ]
Toast [ ]
Why do you prefer them prepared in the way you have indicated……
……
……..……
Do lots of people in this community consume insects?
Yes [ ] No [ ]
Explain……
……..……
……
……
Have you noticed any changes in the quality or appearance of different types of edible insects in the last 10 years? Yes [ ] No [ ]
Explain……
……
……
Have you noticed any changes to insect population in the seasons when insects are available?
Yes [ ] No [ ]
Explain……
……
<u>Household livelihoods</u>
Does your household participate in the sale of edible insects? Yes [ ] No [ ]

Explain……
……
……
Who sells insects in this household?

Young people [ ]

Elderly [ ]

Males [ ]

Females [ ]
Explain.....
.....
.....

Where do you sell these edible insects from?
.....
.....
.....
Who are the customers?.....
.....
.....
What type(s) of insects do you sell?.....
.....
.....
Why sell the type(s) of insects listed above?.....
……....

Explain how the sale of edible insects benefits your household……
……
……
When are the insects sold?.....
.....
How much income do you generate annually from the sale of edible insects?
K 1000-2000 [ ]

K 2000-4000 [ ]

K 5000-10000 [ ]

K Above 10000 [ ]

Appendix 2: Guide for Focus Group Discussion

1. Which type of insect species are frequently consumed and why

2. What influences consumption of insects

3. What safety concerns are associated with insect consumption

4. What attitudes or perceptions do people have concerning edible insects

5. Which category of people are likely to consume or actually consume more insects than others and why

6. Are there changes to levels of insect consumption in this community? Explain

7. Which methods of insect collection are used and why

8. Why does this community perceive insects in a way they do

9. What can be done better to ensure that edible insects contribute to household food security and livelihoods?

10. What hinders insect utilization in this community

11. What are some of the creative insect dishes/meals do you know

12. What is the cultural significance of edible insects to this community

Appendix 3: Observation Schedule

Participant Number:……..
Date:
Location:
Start time:
End time:

1. What to observe: Insect type and Collection Method
Which type(s) of insect are collected
Where they are collected from
When they are collected
How edible insects are collected

2. Preparation methods:
How are edible insects prepared
How are insects consumed
Who prepares insects for consumption
How are insects preserved

3. How to observe:
Transact walks
Engaging in informal conversations
Note taking
Photographs

When to observe:
Observation shall be done as and when there is collection of edible insects by members of the community as well as when a household is preparing insects for consumption

What to ask
Why they use insects
Why specific type of insects
What specific benefits they draw from edible insects
Why they harvest/ prepare edible insects in the way they do
What socio-economic and cultural values they attach to edible insects

Appendix 4: Interview guide for local leadership

What is the cultural importance of edible insects to this community

1. What cultural beliefs are associated with certain types of edible insects

2. Has acculturation had any effects on how edible insects are perceived by the indigenous people in this community? Explain

3. How do you compare levels of insect consumption from the past and recent years among people in this chiefdom? Explain

4. Apart from consumption, how else are edible insects utilized.

5. What is the primary source of knowledge concerning edible insects among members of this community?

6. What changes have you noticed concerning insect availability in the last 2 decades? Explain

7. What is the major hindrance to the practice of insect consumption in this community

8. What is this community doing to ensure sustainable utilization of edible insects?

9. What cultural practices are used to ensure preservation of indigenous knowledge among local people

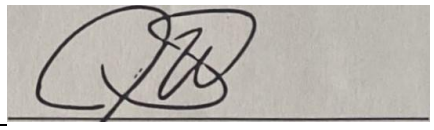
Appendix 5: Research Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Nyawali

CLEARANCE CERTIFICATE	PROTOCOL NUMBER: 1-122/01/22
PROJECT TITLE	Role of edible insects in food security and livelihoods in Zambia
INVESTIGATOR(S)	Mr J Nyawali
SCHOOL/DEPARTMENT	Geography, Archeology and Environmental Studies/
DATE CONSIDERED	28 January 2022
DECISION OF THE COMMITTEE	Approved Risk Level: Minimal
EXPIRY DATE	27 February 2025

DATE 28 February 2022 CHAIRPERSON 

(Professor J Watermeyer)

cc: Supervisor: Professor J Knight

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and ONE COPY returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I [We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved l/we undertake to submit an amendment of the protocol to the Committee. I agree to completion of a regular progress report. For Minimal and Low studies, this is due annually on 31 December. For Medium and High-Risk studies, this is due twice annually on 30 June and 31 December.



Signature Date PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix 6: Information sheet for questionnaire

Role of Edible Insects in Food Security and Livelihoods in Mumbwa District, Central Province, Zambia.

Dear Sir / Madam,

My name is John Nyawali and I am a PhD student in the School of Geography, Archeology and Environmental Studies at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the **Role of Edible Insects in Food Security and Livelihoods in Mumbwa District, Central Province, Zambia** under the supervision of Prof. Jasper Knight. The aim of this research project is to understand how edible insects are utilised in rural areas of Mumbwa district as food and alternative source of livelihoods.

As part of this project, I would like to invite you to take part in answering this questionnaire. I will read out the questions to you and I will be writing the answers provided or tick in the appropriate box. This questionnaire will take around 45-60 minutes to be answered. Data on this questionnaire will be transferred to a laptop computer where it will be stored and secured with a password only the researcher will have access to.

There will be no personal costs to you if you participate in this project. You will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. The questionnaire will be confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. Identifying features will be removed from the final report and information will not be shared with unauthorized individuals. If you experience any distress or discomfort at any point in this process, we will stop the exercise or resume another time.

To prevent the transmission of COVID 19, you will be required to wear a disposable face mask at all times during this exercise. In case you do not have a face mask, I will endeavor to provide a mask and hand sanitizer to you. Further, you will not be required to physically handle the questionnaire as I will read it out for you and I will be writing the answers. The questionnaire will be administered under strict adherence to the rules of social distancing.

This exercise will be read to you in English. However, should you have difficulties understanding English language, the research assistant will endeavor to translate to you in the local language you are conversant. If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (NonMedical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,

John Nyawali

Email: 2533460@students.wits.ac.za
Phone: +260960882704

Supervisor: Prof. Jasper Knight

Email: Jasper.Knight@wits.ac.za

Phone: + 27117176508

Appendix 7: Information sheet for focus group discussion

Role of Edible Insects in Food Security and Livelihoods in Mumbwa District, Central Province, Zambia.

Dear Sir / Madam,

My name is John Nyawali and I am a PhD student in the School of Geography, Archeology and Environmental Studies at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the **Role of Edible Insects in Food Security and Livelihoods in Mumbwa District, Central Province, Zambia** under the supervision of Prof. Jasper Knight. The aim of this research project is to understand how edible insects are utilised in rural areas of Mumbwa district as food and alternative source of livelihoods.

As part of this project, I would like to invite you to take part in a Focus Group Discussion. This discussion will require that you discuss in detail and provide answers to questions that will be asked while I will be writing down the answers provide. I will moderate the discussion and ensure that each participant has equal opportunity to express their views without interruption from me or fellow participants. This face-to-face discussion will take around 60 minutes. With your permission, I would also like to take notes and audio record the discussion using a digital device. This recording will be stored in a laptop computer that will be secured with a password and only I will have access to this recording.

There will be no personal costs to you if you participate in this project. You will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. Anonymity and confidentiality may not be guaranteed in this Focus Group Discussion as it is a group activity, however, I will not be asking for your name or any identifying information, and the information you give to me will be held securely on a laptop computer that will be secured with password and not disclosed to anyone else. Information in the final report will not have identifying features

and will not be shared with unauthorized individuals. If you experience any distress or discomfort at any point in this process, we will stop the discussion or resume another time.

Owing to COVID 19, discussions will be held in open air spaces while observing social distancing. You will be required to wear face masks at all times during discussions. In case you do not have a face mask, I will endeavor to provide a mask and hand sanitizer to you.

This exercise will be conducted in English. However, should you have difficulties understanding English language, the research assistant will endeavour to translate to you in the local language you are conversant. If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online in English through the university library website. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,

John Nyawali
Email: 2533460@students.wits.ac.za
Phone: +260960882704

Supervisor: Prof. Jasper Knight
Email: Jasper.Knight@wits.ac.za
Phone: + 27117176508

Appendix 8: Information sheet for interviews

Role of Edible Insects in Food Security and Livelihoods in Mumbwa District, Central Province, Zambia.

Dear Sir / Madam,

My name is John Nyawali and I am a PhD student in the School of Geography, Archeology and Environmental Studies at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the **Role of Edible Insects in Food Security and Livelihoods in Mumbwa District, Central Province, Zambia** under the supervision of Prof. Jasper Knight. The aim of this research project is to understand how edible insects are utilised in rural areas of Mumbwa district as food and alternative source of livelihoods.

As part of this project, I would like to invite you to take part in an interview. This interview will ask that you answer or explain in detail questions that will be asked in relation to the topic mentioned above while I will be also making notes. This interview will be face to face and will take around 30-45 minutes. With your permission, I would also like to audio record the interview using a digital recorder or phone. This recording will be transferred to a laptop computer where it will be stored and secured with a password only the researcher will have access to.

There will be no personal costs to you if you participate in this project. You will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. The interview will be confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. Identifying features will be removed from the final report and information will not be shared with unauthorized individuals. If you experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.

To prevent the transmission of COVID 19, you will be required to wear a disposable face mask at all times during this exercise. In case you do not have a face mask, I will endeavor to provide a mask and hand sanitizer to you. This interview will be conducted in strict adherence to social distancing and in an open-air space. It is suggested that the interview is conducted at any public place, preferably at Kaindu Primary school.

This exercise will be conducted in English. However, should you have difficulties understanding English language, the research assistant will endeavour to translate to you in the local language you are conversant with.If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,

John Nyawali
Email: 2533460@students.wits.ac.za
Phone: +260960882704

Supervisor: Prof. Jasper Knight
Email: Jasper.Knight@wits.ac.za
Phone: + 27117176508

Appendix 9: Information sheet for ethnographic observations

Role of Edible Insects in Food Security and Livelihoods in Mumbwa District, Central Province, Zambia.

Dear Sir / Madam,

My name is John Nyawali and I am a PhD student in the School of Geography, Archeology and Environmental Studies at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the **Role of Edible Insects in Food Security and Livelihoods in Mumbwa District, Central Province, Zambia** under the supervision of Prof. Jasper Knight. The aim of this research project is to understand how edible insects are utilised in rural areas of Mumbwa district as food and alternative source of livelihoods.

As part of this project, I would like to request you to allow me observe how you collect different types of edible insects. This will entail you moving around collection sites with me, observation of insect preparation methods and engaging in conversations with me. The observations will be done for the period you are collecting edible insects and preparing them for consumption. With your permission, I would also like to take notes and take photographs of this activity. The photographs and field notes will be stored in a Laptop computer that will be secured with a password and only I will have access to this data. I will ensure that your participation remains anonymous and that the information and the final report will not be shared with unauthorized individuals.

There will be no personal costs to you if you participate in this project. You will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. Anonymity and confidentiality may not be guaranteed in conducting observations as it is a group activity, however, I will not be asking for your name or any identifying information, and the information you give to me will be held securely on a Laptop computer that will be secured with password and not disclosed to anyone else. Information in the final report will not have identifying features

and will not be shared with unauthorized individuals. If you experience any distress or discomfort at any point in this process, we will stop the discussion or resume another time.

To ensure safety from COVID 19, you will be required to wear a disposable face mask at all times during this exercise while. In case you do not have a face mask, I will endeavor to provide a mask and hand sanitizer to you.

This exercise will be conducted in English. However, should you have difficulties understanding English language, the research assistant will endeavour to translate to you in the local language you are conversant. If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online in English through the university library website. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,

John Nyawali
Email: 2533460@students.wits.ac.za
Phone: +260960882704

Supervisor: Prof. Jasper Knight
Email: Jasper.Knight@wits.ac.za
Phone: + 271171765 08

Appendix 10: Request letter to conduct research in Kalwanyembe Ward

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

The Councilor
Kalwanyembe Ward
Mumbwa Constituency
Mumbwa district

13th December, 2021

Dear Sir/Madam,

Re: Permission to conduct research in Kalwanyembe ward

My name is John Nyawali. I am a student at University of the Witwatersrand in South Africa. I am currently studying for a Doctor of Philosophy degree (PhD) in the School of Geography, Archaeology and Environmental Studies, Faculty of Science at the University of the Witwatersrand. I am seeking permission to do research in Kaindu Chiefdom, Kalwanyembe ward.

I am conducting research on the role of edible insects (Grasshoppers, Locusts, Flying termites and Caterpillars) in food security and livelihoods in Zambia. Mumbwa district. This research aims at analysing and understanding the degree of acceptability of edible insects and the extent to which they contribute to household food security and livelihoods to people in rural areas of Mumbwa district.

Kaindu area was purposively selected because it is one of the diverse places in the country in terms of demographics, cultural, and socio-economic characteristics and has a high presence of edible insects such as caterpillars, honey bees, locusts, flying termites and grasshoppers.

The research will entail collecting data from head of households, youth and elderly people. I will invite individuals from your community to participate in this study. If they agree, they will be asked to answer questionnaires; participate in focus group discussions and ethnographic observations of collection and preparation methods of the selected edible insects (Caterpillars, Locusts, Grasshoppers and Flying termites). Participants will be asked to give their written or verbal consent before the research begins. Their responses will be treated confidentially, and identities will be anonymous unless otherwise expressly indicated. Individual privacy will be maintained in all published and written data resulting from the study.

The results will be communicated back to the community through the dissertation that will be produced at the end of this research.

The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study.

I therefore request permission in writing to conduct my research in your community. The permission letter should be on your organisation's headed paper, signed and dated, and specifically referring to myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,

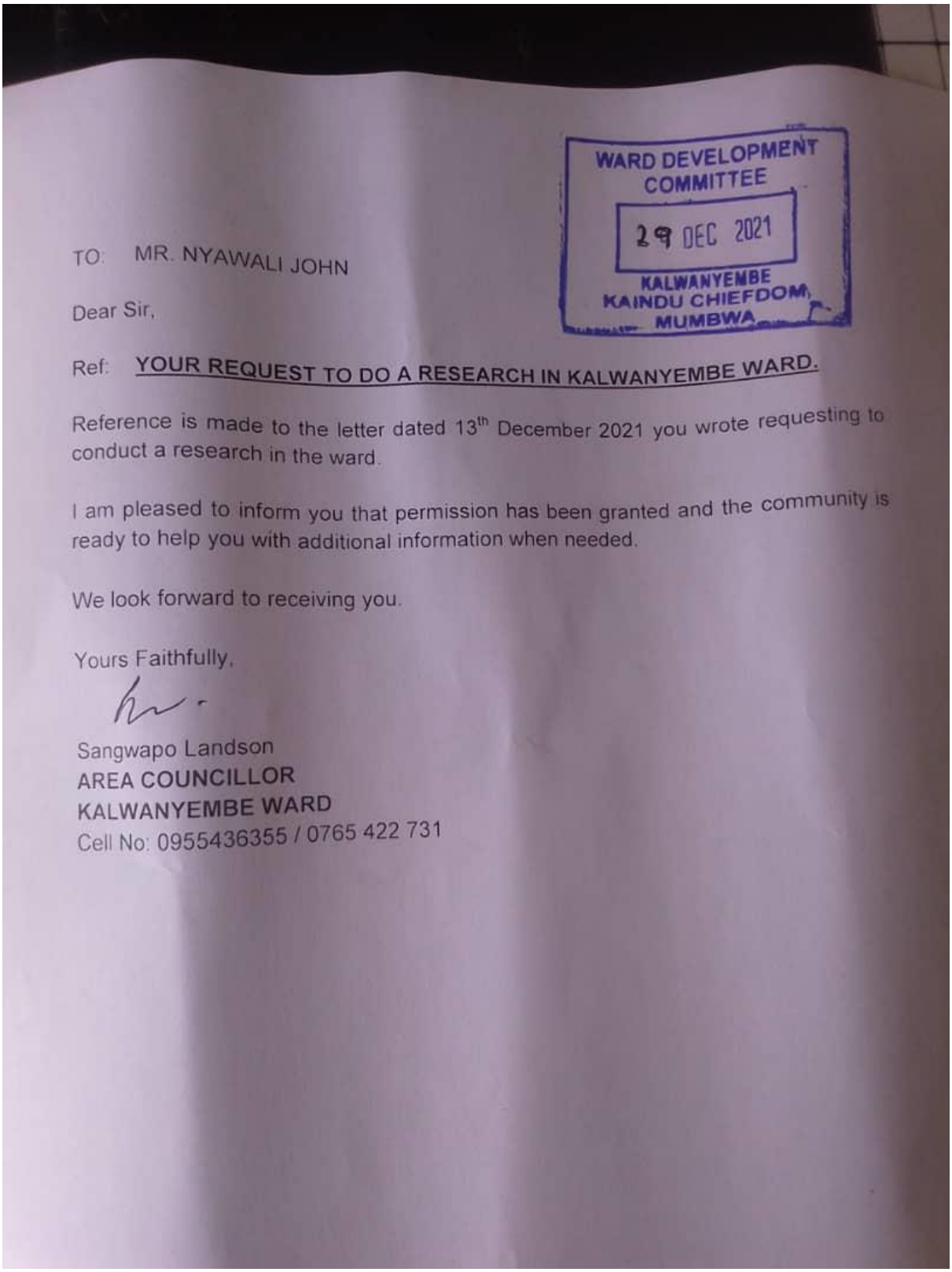


John Nyawali

Contact: +260960882704
Email address: 2533460@] students.wits.ac.za

Supervisor's name: Prof. Jasper Knight
Contact: +27117176508
Email address:Jasper.Knight@wits.ac.za

Appendix 11: Permission letter to conduct research in Kalwannyembe Ward



WARD DEVELOPMENT COMMITTEE
29 DEC 2021
KALWANYEMBE
KAINDU CHIEFDOM,
MUMBWA

TO: MR. NYAWALI JOHN

Dear Sir,

Ref: **YOUR REQUEST TO DO A RESEARCH IN KALWANYEMBE WARD.**

Reference is made to the letter dated 13th December 2021 you wrote requesting to conduct a research in the ward.

I am pleased to inform you that permission has been granted and the community is ready to help you with additional information when needed.

We look forward to receiving you.

Yours Faithfully,

Sangwapo Landson
AREA COUNCILLOR
KALWANYEMBE WARD
Cell No: 0955436355 / 0765 422 731