The effect of the last mile on food security and nutrition in rural Zambia

by

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ABSTRACT

The last mile may constrain socioeconomic development and the achievement of household food security and nutrition as households are remote and distant from public facilities such as roads, health facilities and markets. Households distant from such facilities may find it challenging to buy food, sell agricultural produce and earn incomes. Moreover, food aid organisations may experience difficulties in reaching these communities. For these reasons, remote households may be trapped in food insecurity. Improving the proximity of rural households to public facilities such as all-season roads would ease rural accessibility and foster socioeconomic development and food security.

This study set out to determine how household food security and child nutrition were affected by last-mile factors, i.e., the distance of a household from public facilities. The study employed multivariate regressions and the Tobit model to analyse household food security. In addition, multilevel models were used to regress the last mile variables on child nutrition outcomes.

The study observed a statistically significant and negative influence of the distance from local food and input markets on household food security indicators. However, the coefficients were small, suggesting that proximity to local markets did not significantly affect food security. The lack of a large relationship between the distance to a local market and household food security could be because local markets did not satisfy the market needs of the surrounding households for farm input supplies or markets for crop products. However, the prevalence of underweight among children under five years of age reduced with the proximity to food markets. The results suggested that children living in households close to food markets had greater access to diverse foods.

The food security and nutrition status of households did not depend on the distance from transport facilities and health centres. Distances to transport facilities such as roads did not significantly influence food security because roads were impassable in certain seasons. The lack of a significant effect of the proximity of households to health centres on food security could be because health centres focus on their primary roles, namely disease treatment and prevention. Additionally, the nutrition information from the health centres reached both households near and farther from health centres through the community nutrition volunteers. Therefore, the hypothesis claiming that the last mile affected food security was rejected. In contrast, the hypothesis that the last mile affected child nutrition outcomes was partially accepted.

In conclusion, the last mile did not significantly affect household food security but partially affected the nutrition of children under five years of age. While proximity to health centres and transport facilities did not affect child nutrition, the proximity of a household to a food market reduced the prevalence of underweight. Therefore, nutrition policies should support the establishment of food markets in the last mile to reduce the distances covered to purchase food or sell surplus agricultural products.

DECLARATION

I, James Mukombwe, with student number 18392963, declare that:

1. I am aware of and understand the University policy on plagiarism
2. This dissertation was my original work. Where the study used the work of others, I have acknowledged and referenced according to the university requirements.
3. The work presented is my own. Further, I did not allow anyone to use this dissertation as their own or copy and paste the writings in the document.

Signature:  Date: 30th July 2021

DEDICATION

I dedicate this dissertation to my parents, Mr Charles Mukombwe and Mrs Justinah Muyembe Mukombwe, for their support and encouragement to further my education. Thank you for helping me to raise the academic bar in the family and village.

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LIST OF ACRONYMS

7NDP	Seventh National Development Plan
ADB	African Development Bank
AIC	Akaike's Information Criteria
AUC	African Union Commission
BAZ	BMI- for-Age Z-Scores
BIC	Bayesian Information Criteria
BMI	Body Mass Index
CDDS	Child Dietary Diversity Score
CDI	Crop Diversity Index
CSO	Central Statistics Office
FAO	Food and Agriculture Organization of The United Nations
FISP	Farmer Input Support Programme
FRA	Food Reserve Agency
GDP	Gross Domestic Product
GHI	Global Hunger Index
GRZ	Government of The Republic of Zambia
HAZ	Height-For-Age Z-Scores
IFAD	International Fund for Agricultural Development
IPC	Integrated Food Security Phase Classification
LCMS	Living Conditions Monitoring Survey
LL	Log Likelihood
MDGs	Millennium Development Goals
MoA	Ministry of Agriculture
MoFL	Ministry of Fisheries and Livestock
MTC	Ministry of Transport and Communication
NFNC	National Food and Nutrition Commission
NFNSP	National Food and Nutrition Strategic Plan
OLS	Ordinary Least Squares
RDA	Road Development Agency
RENAPRI	Regional Network of Agricultural Policy Research Institutes
SDG	Sustainable Development Goals
SUN 1st 1000 MCDP	Scaling Up Nutrition First 1000 Most Critical Days Programme
UNSTATS	United Nations Statistics Division
VIF	Variance Inflation Factors
WAZ	Weight-for-Age Z-Scores
WFP	World Food Programme
WHO	World Health Organisation
WHZ	Weight-for-Height Z-Scores
ZDHS	Zambia Demographic Health Survey
ZIPAR	Zambia Institute for Policy Analysis and Research

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CHAPTER 1: INTRODUCTION

1.1 Background to the research problem

The last mile is one of the significant challenges affecting the attainment of food security worldwide (WFP, 2017). The concept of the last mile is used to refer to households or communities that are far from public facilities such as all-season roads, health centres, markets and urban areas (WFP, 2017; Macharis and Melo, 2011). Food security is affected because the last mile communities have poor road networks that limit household access to public facilities such as all-season roads, health centres and markets (Roberts *et al.,* 2006; The World Bank, 2016). Poor access to an all-season road implies households have challenges accessing markets to buy farm inputs to produce their food (Abdi, 2004). Furthermore, poor access to markets impedes households from purchasing various foods or selling their agricultural products (WFP, 2017). As a result, hungry households in the last mile may be trapped in food insecurity and have difficulties reaching out for food assistance (WFP, 2017). Furthermore, even food aid organisations face the challenges of high logistical costs when distributing food assistance to food-insecure households in the last mile communities (WFP, 2017).

The food security situation in last-mile communities is worsened by low return and subsistent-oriented livelihoods associated with poverty. These livelihoods include subsistence farming, the collection of wild foods and other reliance on other natural resources (Khatiwada *et al.,* 2017). Households engaged in these types of livelihoods remain poor because they cannot generate enough income due to inadequate access to credit, farm inputs, markets and infrastructure such as transport facilities (Makuvaro *et al.,* 2017; Miruka and Kabegambire, 2014). These constraints negatively influence food security, leading to low quantities of food produced and available in the communities. Moreover, poor access to transport facilities and distant markets suggest that food produced in neighbouring communities cannot reach the last mile communities resulting in further reduction in food available (WFP, 2017).

The last mile households may engage in crop diversity to enhance physical access to balanced diets (Kissoly *et al.,* 2018; Rehima *et al.,* 2013). However, crop diversity is limited by household access to farm inputs such as seeds and fertilisers, constraining the quantities of different food available for increased nutrition (Sichoongwe *et al.,* 2014). For this reason, most households run out of stocks of some foods leading to low dietary diversity, particularly in lean seasons (Connors *et al.,* 2021; O'Meara *et al.,* 2019). Furthermore, households cannot purchase foods from markets because they do not have adequate income (French *et al.,* 2019). This may result in higher levels of malnutrition (Lambden *et al.,* 2006; Lardea *et al.,* 2011; Webb *et al.,* 2016).

As the global community pursues Sustainable Development Goals (SDGs) related to food security and nutrition, it is essential to implement specific interventions addressing last-mile challenges. This would require evidence relating the last mile to food security and nutrition. Therefore, this study determined the effect of the last mile on food security and nutrition in Zambia's rural areas.

1.2 Problem statement

Zambia experiences high levels of food insecurity, malnutrition and poverty despite producing vast quantities of the staple food, maize (Jayne *et al.,* 2011; Thome *et al.,* 2019). The levels of food insecurity are even higher for rural areas, where 76.6 percent of people lived below the national poverty line in 2015 (CSO and The World Bank, 2016). Furthermore, the 2018 Zambia Demographic Health Survey (ZDHS) reported that the rates of stunting, underweight and wasting for children under five years in rural areas were 35.9 percent, 12.4 percent and 3.8 percent, respectively (CSO *et al.,* 2019). Additionally, the 2019 Integrated Food Security Phase Classification (IPC) report stated that 1.98 million people in Zambia's sampled rural districts were in emergency need of food between October 2020 and March 2021 (FAO, 2020). These statistics have been worrying and caught the eye of policymakers.

Nationwide, 87 percent of the rural population live at least two kilometres away from a transport facility such as an all-season road (The World Bank, 2016). However, this proportion of the rural population reduces to 23.3 percent when the radial distance to a transport facility is increased to five kilometres (CSO and The World Bank, 2016). Chavuma district has the highest rural population (96.6 percent) living beyond two kilometres away from an all-season transport facility compared to 43.8 percent for Ndola district (The World Bank, 2016). Reports also show that 42.5 percent, 45.7 percent and 72.5 percent of the rural population live further than five kilometres away from a health centre, food and farm input markets (CSO and The World Bank, 2016).

These statistics are evidence of the significance of the challenges of food insecurity and the last mile among the households in rural Zambia. Studying the last mile's effects is cardinal in identifying appropriate interventions to pursue SDGs on zero hunger and poverty for Zambia and the global community at large. Several studies attempted to investigate how infrastructure such as roads, health centres and markets affected food security and nutrition. Some of these studies include Ahmed *et al.* (2017), Moroda *et al.* (2018) and Tembo and Simtowe (2009). However, no known study has been conducted in the context of the last mile to determine how proximity to public facilities affected food security and nutrition. Furthermore, unlike the previous studies that used single food security indicators, this study will use seven food security and nutrition indicators to g a comprehensive understanding of the relationship.

Therefore, the results of this study will be essential in planning interventions pursuing the targets of the country's vision 2030 and SDGs on food security and nutrition. Moreover, organisations in the nutrition sector could use the study's findings to strengthen their advocacy for nutrition-sensitive road infrastructure. In the current and former strategic plans guiding nutrition, the Road Development Agency (RDA)'s role has not been recognised, yet evidence in other countries suggested transport played significant roles in nutrition (NFNC, 2011; NFNC, 2017)**.** Additionally, governments could also use the results to convince farmers to join agricultural cooperatives and appreciate advantages such as low cost per unit, increased market bargaining power and income (Aku *et al.,* 2018; Gatare *et al.,* 2015). Finally, the study results will contribute to the debate on whether Zambia should extend or maintain the existing road network. While some organisations (Runji, 2017; The World Bank, 2017; ZIPAR, 2014) view expanding the road network as among solutions to address some of the socioeconomic challenges, Raballand and Whitworth (2012) contend that extending the road network would be uneconomical for Zambia.

1.3 Objectives

This study's overall objective was to determine the effect of the last mile problem on food security and nutrition in the rural areas of the 69 selected districts of Zambia. The overall objective was broken down into the following specific objectives:

1. To determine the effect of household proximity to public facilities on calories per capita from crop production, household expenditure on non-staple foods and crop diversity.
2. To determine the effect of household proximity to public facilities on nutrition outcomes of children under five years of age, i.e. Height-for-Age Z-scores (HAZ), Weight-for-Age Z-scores (WAZ), Weight-for-Height Z-scores (WHZ) and BMI-for-Age Z-scores (BAZ).

Public facilities included health centres, food and input markets and transport facilities. Transport facilities referred to roads, rail and water transport.

1.4 Research hypotheses

The study's first hypothesis was that proximity to public facilities affected calories per capita from crop production, crop diversity and expenditure on non-staple foods. The justification of this hypothesis was that the last mile households had inadequate access to farming inputs such as improved seeds and fertiliser. Some studies found that households closer to transport facilities had increased access to farming inputs (Goyal and Nash, 2017; Mason and Jayne, 2012). Others contended that households with adequate access to farm inputs such as seed increased crop production and crop diversity (Abay and Jensen, 2020; Abdi, 2004; Kiprono and Matsumoto, 2018). Furthermore, proximity to public facilities increased wage employment and self-employment, which are essential determinants of expenditure on non-staple foods (Iimi *et al.*, 2016; Ng *et al.*, 2019; Spey *et al.*, 2019; Wiegand *et al.*, 2017).

The second hypothesis posited that household proximity to public facilities determined nutrition outcomes of children under five years (BAZ, HAZ, WAZ and WHZ). The basis for this hypothesis was that low agricultural diversity in the last mile areas reduced Child Dietary Diversity Scores (CDDS), leading to poor nutrition (Siba 2018). Furthermore, longer distances to roads and markets implied a high cost of reaching those markets (Aranoff *et al.,* 2009; Rehima *et al.*, 2013; Temple and Steyn, 2016). Poor road networks reduced access to wage employment and increased poverty which are important determinants of child nutrition (Shively and Thapa, 2017). Besides, poor road networks implied reduced flow of food from other parts of the country resulting in dependency on locally produced food, mostly staples. Consuming diets with large portions of staples increased child malnutrition (Amaral *et al.,* 2018). Furthermore, even if various local foods were available, mothers could have lacked sufficient food preparation knowledge, resulting in compromising child nutrition (Saaka, 2014). Additionally, accessing clinics that act as essential channels of nutrition information, such as exclusive breastfeeding, was costly since they are far from households (Oyaro, 2017). Under these circumstances, mothers failed to shield their children from poor nutrition, reflecting nutrition outcomes.

1.5 Outline of the dissertation

The content of the dissertation is organised into seven chapters. Chapter one introduced the purpose of the study, its rationale, objectives and hypotheses. Chapter two provides a theoretical review of the literature on the relevant research carried out on food security. Specifically, it provided an in-depth understanding of previously documented literature on the last mile's effect on household food security and child nutrition outcomes. Additionally, it described the theoretical underpinning on which the conceptual framework and the study's methodology were based. Chapter three discusses the food security situation in Zambia regarding food supply, food access and nutrition outcomes. Chapter four discusses the study's methodology, while chapters five and six presented the results obtained from data analysis. Finally, chapter seven presents the conclusion and recommendations based on this study's findings.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Resolving the last mile problem should be a priority for inclusive human development and the reduction of food insecurity, malnutrition and poverty (WFP, 2018). The last mile, characterised by inadequate access to public facilities, is a significant factor driving food insecurity, malnutrition and poverty at the household level (Blimpo *et al.,* 2013; Hwalla *et al.,* 2016; Iimi *et al.,* 2016). Inadequate access to public facilities refers to longer distances covered to access public facilities such as health centres, markets and transport facilities. As a result, the last mile communities may be more vulnerable to food insecurity and challenging to reach in food security emergencies (Skinner *et al.,* 2013).

2.2 Global and African commitments to resolving the last mile

The food insecurity situation in the last mile communities has prompted global commitments to resolve the last mile. The Millennium Development Goals (MDGs) included targets to increase the proportion of the rural population with access to all-season roads, health facilities and markets (The African Union, 2005). The African Heads of States reaffirmed their commitment to making public facilities such as health centres available to households in support of the MDG targets on child health and nutrition (Sambo *et al.,* 2011). The transition from the MDGs to the Sustainable Development Goals (SDGs) saw an even stronger commitment to resolving the last mile. The two SDGs themes, "*leaving no one behind*'' and "*endeavouring to reach the furthest behind first*", show the recognition of the last mile as a problem requiring an urgent solution (United Nations, 2016). Specifically, one of the targets of SDG nine focuses on increasing the proportion of the rural population living within two kilometres of an all-season road (UNSTATS, 2017). Another target in SDG 11 seeks to increase the population with convenient access to public transport (UNSTATS, 2017). However, there are no specific targets related to increasing the proportion of the rural population with access to other public facilities such as health centres and markets that are essential to food security and nutrition.

In Africa, central policy agendas have not been explicit on resolving the challenges imposed by the last mile. For example, despite the understanding that they play important roles in food security and poverty reduction, the African Union's Vision 2063 does not have targets related to the last mile, such as rural access to an all-season road, health centres and markets (ADB, 2014; Cervigni *et al.*, 2017; AUC, 2015). However, Agenda 2063 has a general commitment to increase access to transport, market and health care facilities.

Resolving the last mile problem is important for three reasons. First, resolving the last mile problem is essential to meet the targets of most SDGs, including those relating to poverty and food security, i.e. SDGs one and two (Cook *et al.,* 2017). Reducing the distance between a household and public facilities such as roads and markets could foster socio-economic development (The World Bank, 2016). Second, Macharis and Melo (2011) and Onghena (2008) have contended that the last mile is costly in the delivery of food and non-food items to communities through the commercial sector. Food assistance agencies concur. The last mile imposes high logistical costs in distributing food to hungry households (Roubert *et al.*, 2018). Humanitarian agencies spend a considerable portion of their budgets on logistics that could be used to increase the amount of food provided to these needy communities (Roubert *et al.,* 2018). Furthermore, due to the high cost of logistics, households engaged in agriculture also find it challenging to buy inputs and take their produce to markets, increasing food waste (WFP, 2017). Thirdly, undernutrition in the last mile could lead to long term costs (Temple and Russell, 2018). Undernutrition can reduce the country's Gross Domestic Product (GDP) (Abdul Manap and Ismail, 2019; Byaruhanga *et al.*, 2014; Strauss and Thomas, 1998).

The following subsections discuss the three main challenges faced by the last mile in more detail. The discussions are supported by empirical evidence of how these challenges impede food security and nutrition.

2.3 Households in last-mile communities have poor access to all-season transport facilities

The first characteristic of last-mile communities is that they are far from an all-season transport facility (WFP, 2017). Feeder roads connecting households to all-season roads may become impassable during rainy seasons (WFP, 2017). Moreover, households may not use rail and water transport facilities because of the distances to access them, or these facilities may not be well developed (Toro 2016). Scholars in rural development argue that ensuring that households are within two kilometres of an all-season road can foster socio-economic development (The World Bank, 2016).

Using this rationale, the World Bank uses a radius of two kilometres from an all-season road to define rural accessibility (Roberts *et al.*, 2006; World Bank, 2016). According to the 2016 World Bank report, 31.7 percent of the global rural population were further than two kilometres away from an all-season road (The World Bank, 2016). Figure 2.1 shows that sub-Saharan

Africa has the highest proportion of the rural population living further than two kilometres from an all-season road.

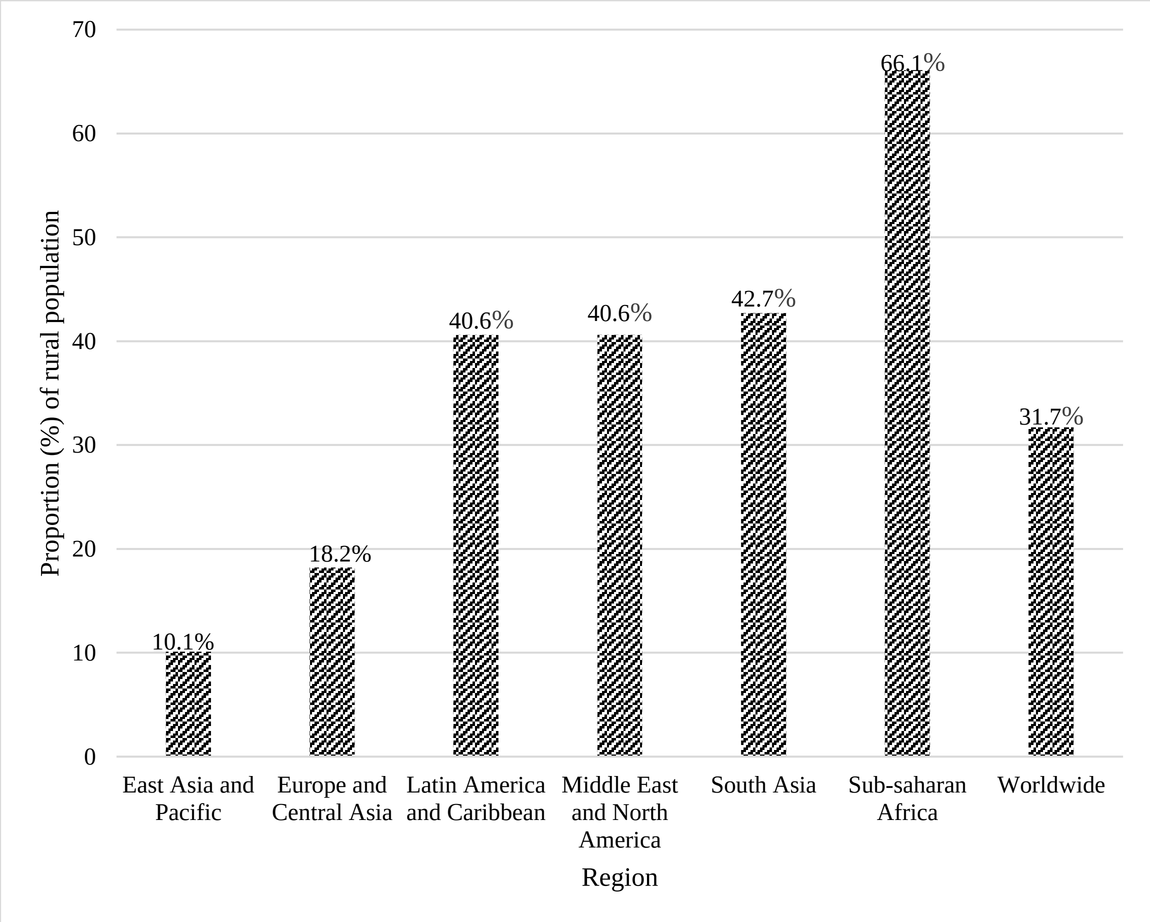

Figure 2.1: The proportion of the rural population living more than two kilometres from an all-season road by region

Source: The World Bank (2016).

A 2016 World Bank report stated that over 75 percent of the rural population in Ethiopia, Mozambique, Tanzania and Zambia lived further than two kilometres of all-season roads (The World Bank, 2016). Furthermore, over half of the rural population in these countries lived further than five kilometres from an all-season road (The World Bank, 2016). In contrast, less than half the rural population in Bangladesh, Kenya, Nepal and Uganda lived further than two kilometres from an all-season road (The World Bank, 2016). However, less than 30 percent of the rural population in the countries mentioned above lived further than five kilometres from all-season roads, as shown in Figure 2.2.

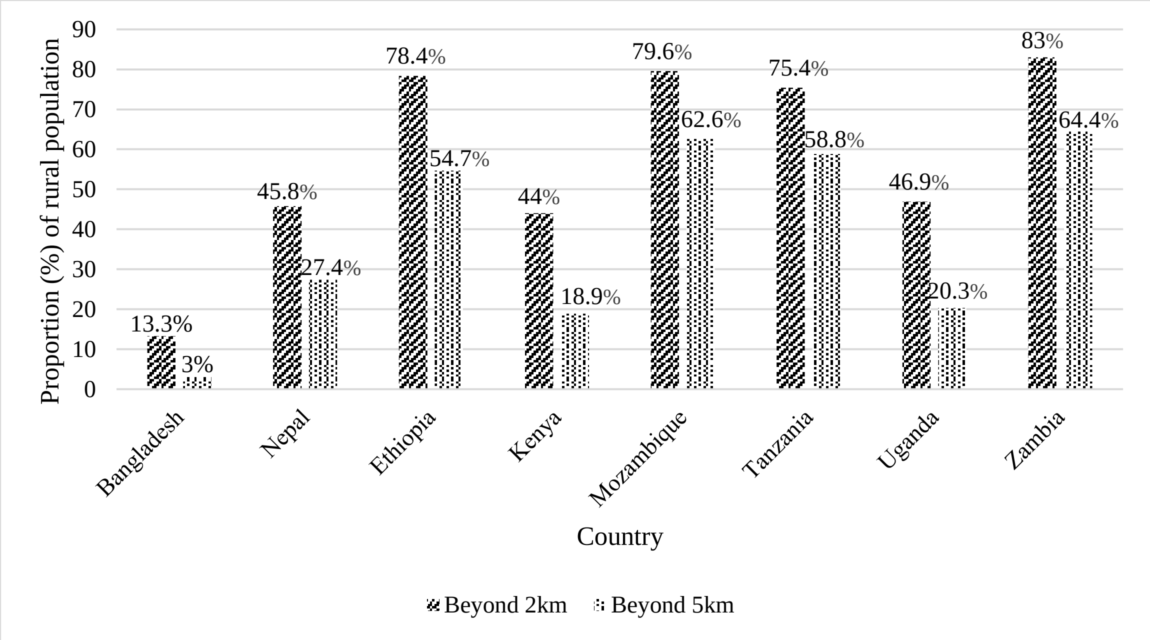

Figure 2.2: The proportion of the rural population living more than two and five kilometres from an all-season road by country

Source: The World Bank (2016).

Several empirical studies have investigated the effect of transport facilities on food security and nutrition. For example, a study conducted in Ghana found that extending the road network by 10 percent resulted in a one percent increase in agriculture output (Benin *et al.*, 2008). This was because a more extensive road network made the movement of farm inputs easier (Abdi, 2004). However, Fungo *et al.* (2017) observed that the proximity of a household to a road did not affect the quantity of crop produced. Fungo *et al.* (2017) explained that roads surrounding farming households did not play a significant role in crop production because most roads were impassable during certain seasons of the year. On the contrary, Tamene and Megento (2017) observed that households near all-season roads had higher crop productivity than households further away because of reduced transport costs for accessing farm input and output markets.

Ashfaq *et al.* (2008) observed that households that were closer to roads also had higher crop diversity. However, Kissoly *et al.* (2018) observed more crop diversity among households far from all-season roads than households near all-season roads. As distance from all-season roads increased, households engaged in crop diversity to meet their nutritional needs and attain self-sufficiency to avoid the costs of accessing food markets (Kissoly *et al.*, 2018).

The proximity of a household to a road positively influences both child and household dietary diversity (Headey *et al.*, 2019; Koppmair *et al.*, 2017; Moroda *et al.*, 2018; Shively and Thapa, 2017). According to Koppmair *et al.* (2017), dietary diversity among households closer to markets was higher because households had access to wage employment to purchase other foods available in markets. This was consistent with Matita *et al.* (2021)'s observation that households that purchased food from the markets had higher dietary diversity scores and better nutrition than households that consume their own produced food.

A study in Nepal observed that living closer to all-season roads increased household share of expenditure on non-staple foods (Shively and Thapa, 2017). This was because an extensive road network reduced poverty and increased access to economic activities such as wage employment (Iimi *et al.,* 2016; Ng *et al.,* 2019).

Access to transport facilities such as roads could improve child nutrition. For example, a study in Nepal observed that children's Height-for-Age Z-scores (HAZ) increased by 0.02 on average, if the time taken to reach an all-season road reduced by one hour (Shively and Thapa, 2017). Similarly, another study in Uganda observed that children living fewer kilometres away from all-season roads had greater linear growth than their counterparts living more kilometres away from the same roads (Kikafunda *et al.*, 2014). This could be because children in households closer to roads have increased access to diverse foods available in markets (Abay and Hirvonen, 2017). On the contrary, a study in Rwanda by Weatherspoon *et al.* (2019) found no influence of proximity to a road on child nutrition.

2.4 Households in the last mile may have poor access to markets and urban centres

Last-mile households may have poor access to farm inputs and food markets to buy food or sell their agricultural products. This may worsen household food security because households may not grow enough food due to poor access to farm inputs (Abdi, 2004; Sunderland, 2011). On the other hand, access to markets may grant access to food throughout the year and in cases of production shortfalls (Gupta *et al.,* 2020). Moreover, access to markets could enhance access to food since households with access to markets have increased access to wage employment (Adler *et al.,* 2020; Aku *et al.,* 2018).

A study conducted in Tanzania found that the quantity of crop production increased with the distance between a household and a major market (Fungo *et al.,* 2017). The observed positive effect of the distance to a major market could be because households distant from major markets had access to more arable land from which they produced bulk quantities, associated with low transportation cost per unit (Fungo *et al.,* 2017). Nonetheless, the quantity of crop production did not significantly change with household proximity to local markets and the roads (Fungo *et al.,* 2017). Thus, Fungo *et al.* (2017) argued that local markets did not necessarily satisfy the market needs of the surrounding farm households because the market may not supply all the farm inputs necessary and provide a reliable market to sell crops.

Tamene and Megento (2017) observed that households closer to major markets in Ethiopia had higher crop productivity. Being located closer to a market reduced the cost of accessing markets for farmers to purchase farm inputs or sell their crop produce (Tamene and Megento, 2017). A 2019 study conducted in Ethiopia on milk production concurred, finding that households located near markets produced a greater quantity of milk than households that were further away (Abay and Jensen, 2020). However, Abay and Jensen (2020) concluded that this relationship was weak as it was only significant at the ten percent level of statistical significance.

Having access to markets could influence crop diversity. For example, studies conducted in Ethiopia and Zambia observed that households that are further away from a market produced more diverse crops to meet their consumption needs and avoid the transactional costs of purchasing food from markets (Misselhorn and Hendriks, 2017; Rehima *et al.,* 2013; Sichoongwe *et al.,* 2014). On the contrary, a study in India found that farming households nearer to markets had higher crop diversity than households situated far away (Ashfaq *et al.,* 2008). The increased crop diversity with proximity to markets could be because farming households closer to markets incur lower transportation costs to access markets where they sell their produce (Ahmed *et al.,* 2017). Meanwhile, access to markets increased a household's share of expenditure on non-staple foods due to increased access to wage employment (Iimi *et al.,* 2016; Ng *et al.,* 2019; Shively and Thapa, 2017).

Studies by Darrouzet-Nardi and Masters (2015) and Abay and Hirvonen (2017) found that children living in households closer to food markets and urban centres were better nourished. Similarly, studies conducted in Uganda and Nepal observed that children living closer to markets were taller than their counterparts living further away from the same markets (Kikafunda *et al.,* 2014; Shively and Thapa, 2017). Children living closer to markets may be taller because they had access to various nutrient-dense foods available in the markets compared to children living further away (Darrouzet-Nardi and Masters, 2015; Headey *et al.,* 2019; Moroda *et al.,* 2018). However, Darrouzet-Nardi and Masters (2015) argued that in certain cases, consumption of foods sold in supermarkets could increase the chance of being overweight, particularly in adults due to higher access to calorie-dense processed foods (Darrouzet-Nardi and Masters, 2015).

2.5 Households in the last mile may have poor access to health centres

Last-mile households are also often located far from health centres, yet health centres are essential channels of nutrition information and care (Quaidoo *et al.,* 2018). Increased access to nutritional knowledge and information provided by the health centres and general health care could enhance nutrition outcomes (Nankinga *et al.,* 2019). This could explain Kikafunda *et al.* (2014)'s findings in a Ugandan study that children under five years of age who lived in households close to health centres are less likely to be stunted. Another study conducted in Ghana found that households that accessed a health facility within 15 minutes had higher crop output (Benin *et al.,* 2008). On the contrary, a 2018 study conducted in Ethiopia by Moroda *et al.* (2018) observed that dietary diversity increased with distance from a health facility. However, proximity to a health facility may not affect food security and nutrition if community health volunteers disseminate nutrition messages in both communities far and near health facilities (Juarez *et al.,* 2021; Muremyi, 2020). This is because community health volunteers could reach out with nutrition lessons to households near and far from health facilities (Juarez *et al.,* 2021; Muremyi, 2020).

In summary, the proximity to public facilities could affect food security and nutrition. Table 2.1 below summarises the findings of some of the studies discussed above with their respective methodologies**.**

Table 2.1: Summary of the findings and methodologies of the selected similar studies

Dependent variable	Independent variable	Sign observed	Methodology	Sample size	Country	Reference
Child stunting status (stunted =1)	Non-staple food expenditure	-	Binary logistic regressions	N*T =6101	Uganda	(Amaral *et al.*, 2018)
Crop diversity	Distance to a road	+	Poisson regressions	899 HHs	Tanzania	(Kissoly *et al.*, 2018)
Crop diversity	Distance to a market	+	Tobit, Heckman	1555 HHs	Zambia	(Sichoongwe *et al.*, 2014)
Crop diversity	Distance to a market and road	+	Poisson and Tobit	307 HHs	Nepal	(Gauchan *et al.*, 2005)
Crop diversity	Household head age	+	Multinomial logit	134 HHs	Mali	(Dembele *et al.*, 2018)
Crop productivity	Distance to a market and road	-	Multivariate regression	500 HHs	Ethiopia	(Tamene and Megento, 2017)
HAZ	Time of travel to a road and market	-	Multilevel regression	2368 children	Nepal	(Shively and Thapa, 2017)
HAZ	Distance to road, market and health centre	-	Logistic regression	391 children	Uganda	(Kikafunda *et al.*, 2014)
HAZ	Household head grade	+	Reduced form production function	10388 children	Zambia	(Masiye *et al.*, 2010)
HAZ	Crop diversity	+	Multivariate regression	36535 HHs	S.Saharan Africa	(Tobin *et al.*, 2019)
Quantity of crop produced	Minutes of travel to reach a health centre	-	Simultaneous Equation Approach	4013 HHs	Ghana	(Benin *et al.*, 2008)
Quantity of crop produced	Distance to a major market	+	Ordinary Least Squares	5015 HHs	Tanzania	(Fungo *et al.*, 2017)
Quantity of crop produced	Asset value	+	Simultaneous Equation Approach	4013 HHs	Ghana	(Benin *et al.*, 2008)
Share of exp. on non-staple foods	Time taken to reach a market and road	-	Multilevel regression	3937 HHs	Nepal	(Shively and Thapa, 2017)
Share of exp. on non-staple foods	Dependency ratio	-	Multilevel regression	3937 HHs	Nepal	(Shively and Thapa, 2017)
WAZ	Per capita expenditure	+	Reduced form production function	10388 children	Zambia	(Masiye *et al.*, 2010)

2.6 Other factors affecting food security

Other than the last mile factors, food security is affected by socio-economic and demographic factors. For example, the quantity of crop produced is known to increase with the size of the farm (Anigbogu *et al.*, 2015). This could be attributed to the increased quantities of farm inputs known to directly positively affect crop yield (Yousaf *et al.*, 2017). However, increasing the plot size beyond a certain hectarage with fixed farm inputs could reduce crop yield since the inputs are spread over a large plot (Brambilla and Porto, 2006). Other studies argue that the size of a plot cultivated reduced the number of stunted children (Blimpo *et al.*, 2013). This is consistent with Cordero-Ahiman *et al.'s* (2021) finding that households that cultivate large hectarages have higher dietary diversity due to increased crop diversity.

Nonetheless, other studies observed that dietary diversity increased among households that engaged in food purchases than households that depended on their production (Matita *et al.*, 2021). Households involved in food purchases could access various food on the market in all seasons, unlike households dependent on their production, whose dietary diversity reduces in lean seasons (Matita *et al.*, 2021; O'Meara *et al.*, 2019). A 2021 study in India observed that households engaged in monocropping had the most significant reduction in dietary diversity in the lean season compared to households that had crop diversity (Connors *et al.*, 2021).

Adult labour, defined as the proportion of household members aged 18 to 64 years, has a positive relationship with the quantity of crop produced by a household (Benin *et al.*, 2008). This relationship could be attributed to the fact that adult labour represents the labour available to work in family farms (Ngongi and Urassa, 2014). However, the quantity of crop produced reduced with household size (Benin *et al.*, 2008; Ngongi and Urassa, 2014). It was contended by Ngongi and Urassa (2014) that the negative relationship was the result of many financial responsibilities associated with larger households. Other studies observed that larger households were associated with a reduced share of expenditure on non-staple food and child linear growth (Geberselassie *et al.*, 2018; Shively and Thapa, 2017). The negative effect of household size could be explained by the economic challenges and struggles of poverty associated with larger households (Cleland *et al.*, 2006; Geberselassie *et al.*, 2018).

Crop diversity has been observed as higher among male-headed households (Dessie *et al.*, 2019; Dube, 2016; Kissoly *et al.*, 2018). According to Dessie *et al.* (2019), male-headed households increased crop diversity compared to female-headed households because they were risk-takers and had increased access to resources such as land. Other studies argued that female-headed households had higher crop diversity to ensure increased income and enhanced food security and nutrition (Rehima and Dawit, 2012; Rehima *et al.,* 2013). Meanwhile, crop diversity could increase if the household worked in the agricultural sector (Dube, 2016). The study attributed the difference in crop diversity to the increased knowledge of agriculture among household heads that worked in the agricultural sector (Dube, 2016). Additionally, crop diversity could increase among households with self-employed household heads (Kissoly *et al.,* 2018). This is because self-employed household heads are more likely to have a higher income that enables them to purchase farm inputs for different crops (Goetz *et al.,* 2012; Kissoly *et al.,* 2018; Narain and Jeffers, 2020).

According to studies in Nepal, households with higher crop diversity tend to have a higher expenditure on non-staple foods (Kumar *et al.,* 2020; Shively and Thapa, 2017). However, the findings of some authors that crop diversity increased dietary diversity could suggest that households that grow enough of the various foods become self-sufficient, resulting in reduced expenditure on non-staple foods (Kissoly *et al.,* 2018; Shively and Thapa, 2017; Zani *et al.,* 2019).

Expenditure on non-staple foods is higher among wealthy households than poor households (Shively and Thapa, 2017). This observation was consistent with Bennet's law stating that increased income resulted in households switching from starchy diets to non-staple foods (Godfray, 2011).

Female children often have better nutrition outcomes than their male counterparts, as observed in Nigeria, Rwanda and Zambia (Akombi *et al.,* 2017; Masiye *et al.,* 2010; Nshimyiryo *et al.,* 2019). In certain societies, female children were favoured over male children, leading to poor nutrition among male children (Chirande *et al.,* 2015; Mzumara *et al.,* 2018). Others argued that the gender differences in child nutrition could be explained by biological differences such as the increased likelihood of morbidity in male children compared to female children (Elsmén *et al.*, 2004; Kilbride and Daily, 1998; Masiye *et al.,* 2010). However, Sapkota and Gurung (2009) contended that male children had better nutrition than girls. Sapkota and Gurung (2009) stated that gender discrimination against females could have affected the nutrition of girl children in certain societies.

Several studies found that child nutrition deteriorates as children grow (Bwalya *et al.,* 2015; Masiye *et al.,* 2010; Nankinga *et al.,* 2019). This could be because the intensity of child care among parents reduces as children grow up (Masiye *et al.,* 2010). Furthermore, inadequate nutrition when the child is introduced to complementary foods could explain the poor nutrition in older children than their younger counterparts (Bwalya *et al.,* 2015; Mokori *et al.,* 2017). Still, others argue that poor nutrition in children could result from contamination of complementary foods leading to increased diarrhoea, a risk factor for child malnutrition (Gupta, 2014; Kosek *et al.,* 2013). Meanwhile, children living with their biological mothers are well-nourished than children not living with their biological mothers (Habimana and Biracyaza, 2019). The result suggested that children who lived with their biological mothers had better care than their counterparts who did not live with their biological mothers (Habimana and Biracyaza, 2019; Masiye *et al.,* 2010).

Maternal age and education positively correlated with the nutrition status of children under five years (Bwalya *et al.,* 2015; Mzumara *et al.,* 2018; Nankinga *et al.,* 2019). Educated mothers were likely to have increased access to nutritional information, which is one of the drivers of child nutrition (Nankinga *et al.,* 2019). In addition, knowledge of child nutrition was likely to be higher in older mothers than younger mothers due to differences in nutritional care experience (Nankinga *et al.,* 2019). However, nutrition for children whose mothers are older is likely to deteriorate if mothers have several children under five years since the quality of care is likely to reduce (Nankinga *et al.,* 2019).

Another study conducted in rural areas selected from Ghana, Rwanda, Malawi, Mali, Nigeria, Senegal and Uganda found that livestock ownership positively affected child nutrition (Hetherington *et al.,* 2017). This could be because children were living in households that reared animals consumed animal source foods such as meat and milk that enhanced their nutrition (Headey *et al.,* 2018).

2.7 The last mile situation in Zambia

Zambia's long term policy document, the Vision 2030, recognises the need to reduce the distance travelled by household members to access public facilities (GRZ, 2006). By 2030, Zambia targets to have about 75 percent and 80 percent of its population accessing basic schools and health facilities within five kilometres (GRZ, 2006). The Vision 2030 is broken down into five-year national development plans, with the current being the 7th National Development Plan (7NDP). The 7NDP, which was themed "… *without leaving anyone behind*", aims to increase the proportion of the rural population accessing markets, health facilities and schools within five kilometres by 2021 (GRZ, 2018). Meanwhile, the national transport policy envisions Zambia with an efficient transport system by 2028 (MTC, 2019).

Based on this review of Zambia's policies, there is a commitment to address the last mile in Zambia.

About 73 percent of the rural population in Zambia live more than five kilometres away from a farm input market (CSO and The World Bank, 2016). However, most of Zambia's rural population live within five kilometres of either a road, rail or water transport point, as shown in Figure 2.3. Other reports state that 83 percent of Zambia's rural population live more than two kilometres away from an all-season road (The World Bank, 2016). This implies that rural inaccessibility, defined as the proportion of the rural population living more than two kilometres away from an all-season road, is high for Zambia compared to other sub-Saharan African countries such as Ethiopia, Kenya, Mozambique, Tanzania and Uganda.

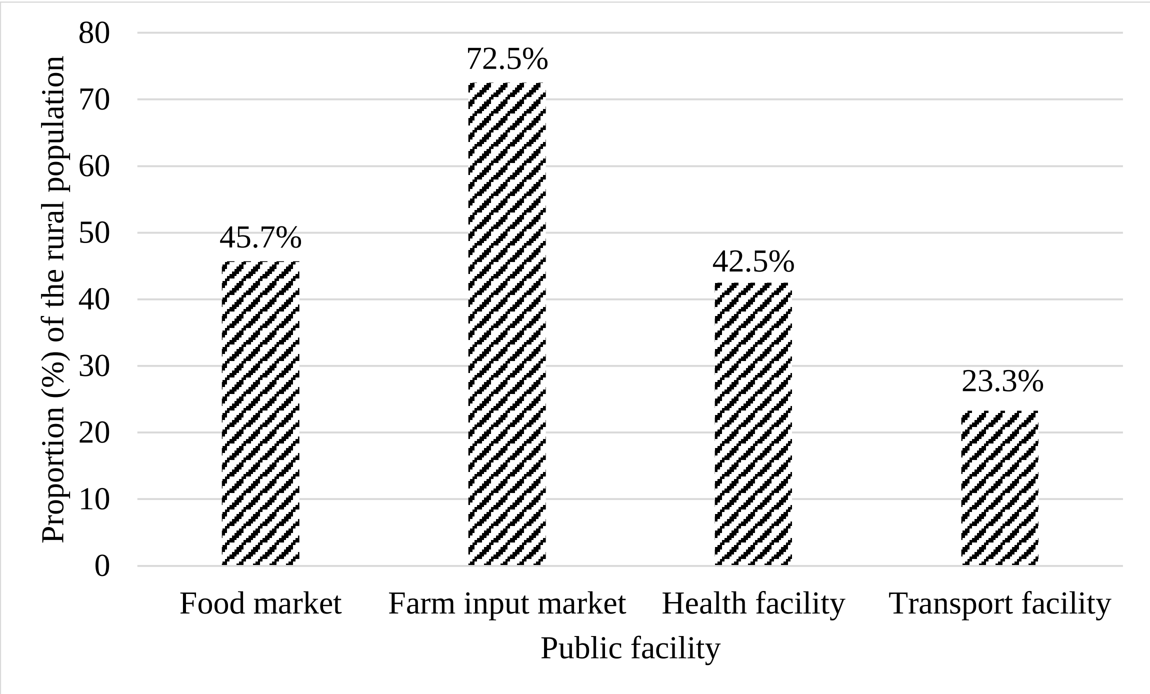

Figure 2.3: The proportion of the rural population living beyond five kilometres from a public facility

Source: LCMS 2015 report (CSO and The World Bank, 2016).

Table 2.2 shows that rural inaccessibility was very high for certain districts in Zambia. For example, Chavuma district had rural inaccessibility of 96.6 percent.

Table 2.2: The proportion (%) of the rural population living beyond two kilometres from an all-season road

District	%	District	%	District	%	District	%
Chadiza	64	Kasama	78.9	Kalabo	90.8	Mungwi	88.5
Chama	95.2	Kasempa	87.3	Kalomo	86.3	Mwense	80.5
Chavuma	96.6	Katete	72.3	Kalulushi	88.7	Mwinilunga	92.1
Chibombo	84.6	Kawambwa	86.1	Kaoma	86.5	Nakonde	71.3
Chienge	78.4	Kazungula	92.4	K. Mposhi	90.8	Namwala	92.2
Chililabombwe	95	Kitwe	74.5	Kaputa	88.3	Nchelenge	84
Chilubi	91.3	Livingstone	45.7	Mbala	85.9	Ndola	43.8
Chingola	83.6	Luangwa	88.1	Milenge	85.8	Nyimba	74.5
Chinsali	84.6	Luanshya	80.4	Mkushi	84.8	Petauke	85.7
Chipata	65.7	Lufwanyama	92.1	Mongu	83	Samfya	88.3
Choma	70.3	Lukulu	93.4	Monze	78.3	Senanga	90.1
Chongwe	79.5	Lundazi	85.5	Mpika	91.2	Serenje	85.9
Gwembe	92.2	Lusaka	96.1	Mpongwe	86.8	Sesheke	91.9
Isoka	77.6	Luwingu	86.6	Mporokoso	76.4	Shang'ombo	94.2
Itezhi Tezhi	82.8	Mambwe	81.5	Mpulungu	58.8	Siavonga	78.2
Kabompo	89.1	Mansa	78.1	Mufulira	78.8	Sinazongwe	76.2
Kabwe	50.9	Masaiti	84.6	Mufumbwe	94.2	Solwezi	91.9
Kafue	69.3	Mazabuka	69.3	Mumbwa	90.8	Zambezi	91.3

Source: The World Bank (2016).

As Zambia pursues achieving food security and eliminating all forms of malnutrition by 2030, addressing the challenges imposed by the last mile becomes crucial (NFNC, 2017, 2019). To add, studies relating the last mile to food security and nutrition become essential to provide evidence for policy planning.

2.8 The research gap

Several studies investigated the factors that affect food security and nutrition. Some of these studies included variables of proximity to public facilities. Therefore, no known studies fully focused on how the last mile affected food security and nutrition. Unlike the previous studies that used single last-mile indicators, this study will regress several food security indicators on distances to a transport facility (road, rail or water), health centre, food and farm input market to get a comprehensive understanding of the relationship. Additionally, this study will include the effects of other transport facilities such as rail and water transport, which previous studies did not consider.

2.9 The conceptual framework

The literature review identified the main last-mile indicators as household proximity to public facilities such as markets, health facilities and all-season roads (WFP, 2017). The relationship with food security was conceptualised as shown in Figure 2.4.

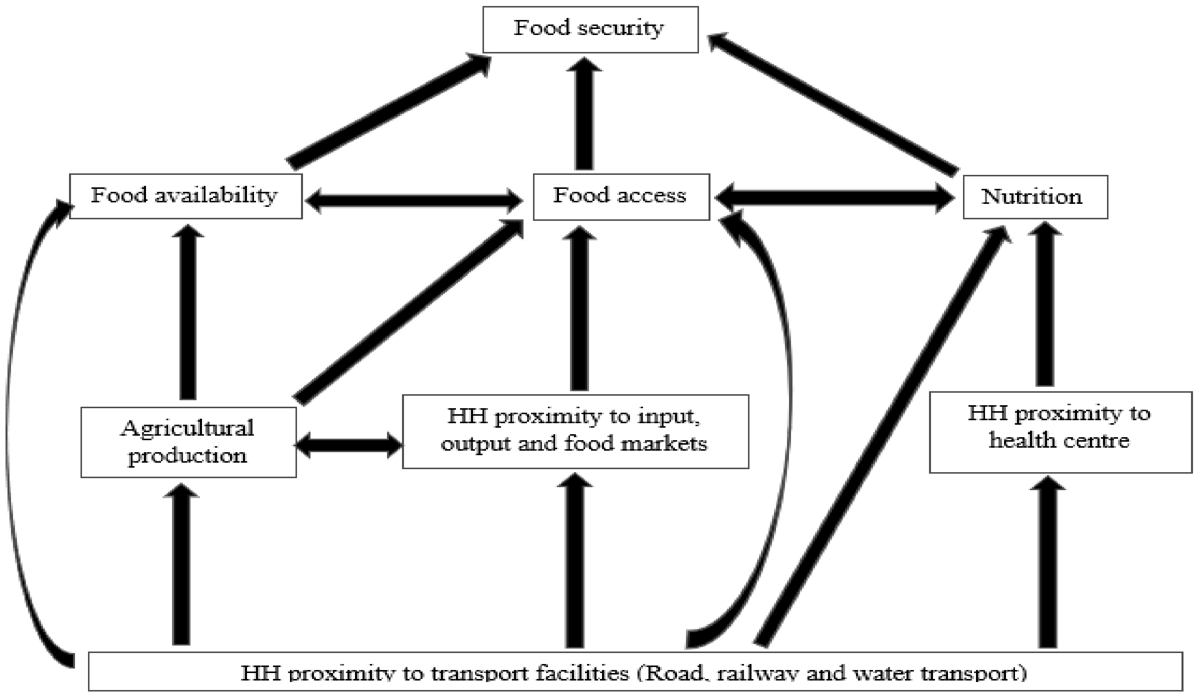

Figure 2.4: The conceptual study framework

Source: Author's own analysis of literature reviewed

As shown in the conceptual framework given above, household access to an all-season transport facility could affect household access to markets and health centres (Roberts *et al.,* 2006; Stifel *et al.,* 2016; The World Bank, 2016). Access to markets and health centres, in turn, affects the components of food security, namely food availability, access and nutrition.

CHAPTER 3: FOOD SECURITY AND NUTRITION SITUATION IN ZAMBIA

3.1 Overview of policies affecting food security in Zambia

Zambia's long term vision is to be "a prosperous middle-income nation by 2030" (GRZ, 2006). In terms of food security and nutrition, the Zambian Vision 2030 aims to have "*a well-nourished and healthy population by 2030*" (GRZ, 2006). The Vision 2030 was broken down into specific targets stated in the National Food and Nutrition Strategic Plan (NFNSP), which seek to eliminate all forms of malnutrition by 2030 (NFNC, 2019). The NFNSP gives special attention to children under two years of age and women of childbearing age as the two groups are in critical need of adequate nutrition. In addition to the NFNSP, Zambia's nutrition sector was guided by the Scaling Up Nutrition First 1000 Most Critical Days Programme (SUN 1st 1000 MCDP), whose targets included reducing stunting of children under five years of age to 25 percent and increasing dietary diversity scores for women and children by 50 percent (NFNC, 2017).

3.2 Food availability in Zambia

Zambia boasts of a climate that is suitable for the production of a variety of foods. The country has three climatic regions, i.e. region I, region IIa, region IIb and region III, which support the production of different agricultural products, as shown in Figure 3.1 (MoA and MoFL, 2016). The production of maize, the most prominent crop in Zambia's agricultural sector, performs well in region IIa, covering parts of Southern, Central, Lusaka and Eastern provinces. The rest of the crops grown in different provinces are given in Figure 3.1 below.

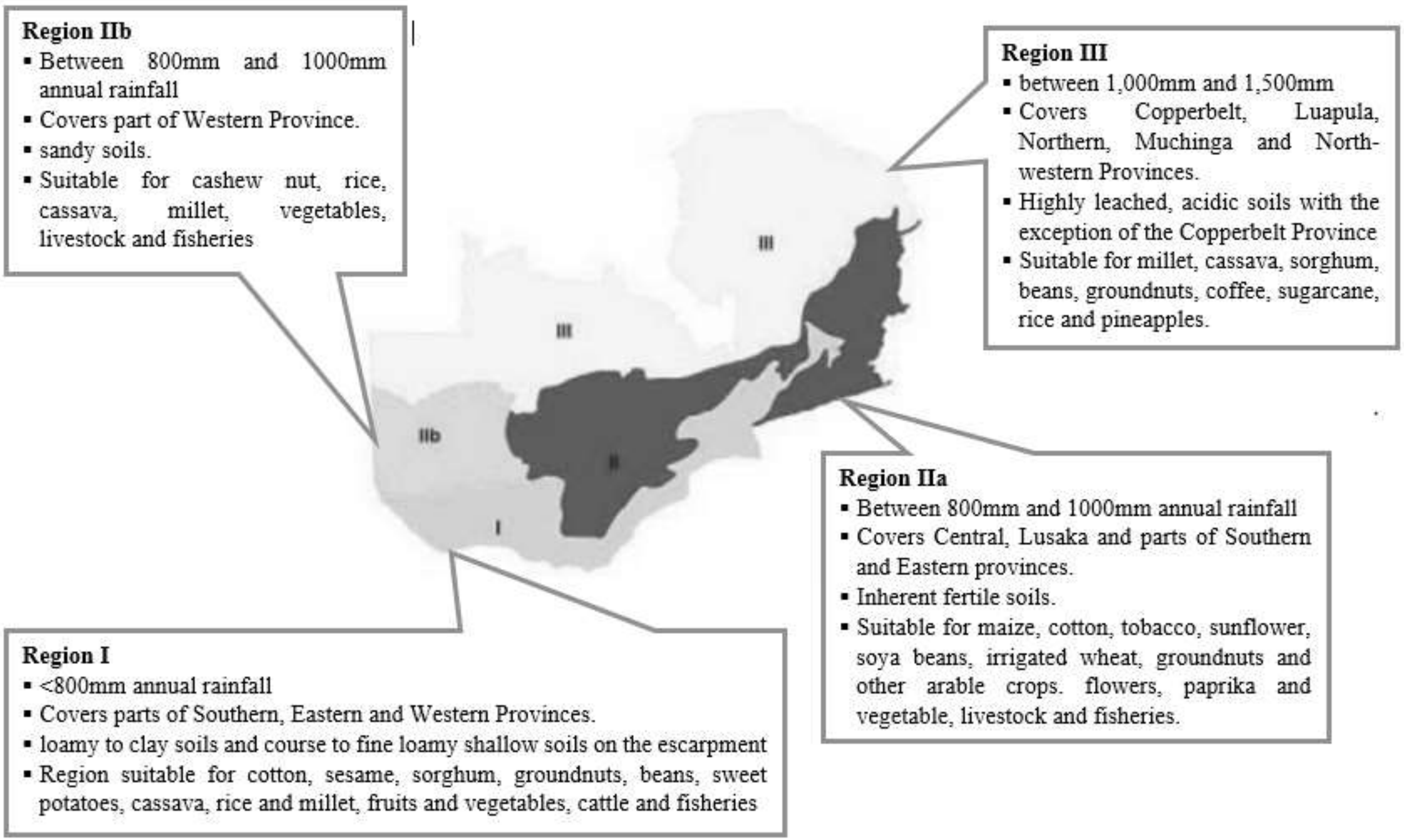

Figure 3.1: Zambia's climatic regions and the most suitable type of agriculture

Source: (MoA and MoFL, 2016)

Zambia's of food production has generally been rising since 2004. The Ministry of Agriculture (MoA) reported overall increments in the quantities of groundnuts, maize, rice, soybeans, sunflower and wheat produced between 2004 and 2015, as shown in Figure 3.2 below. For example, the maize yield increased from about 1.2 million to about 2.6 million tonnes during this period (MoA and MoFL, 2016) and was projected to increase further (ReNAPRI, 2014). During the same period, smallholder farmer productivity for maize also increased from 1.93 tonnes to 2.24 tonnes per hectare (MoA and MoFL, 2016).

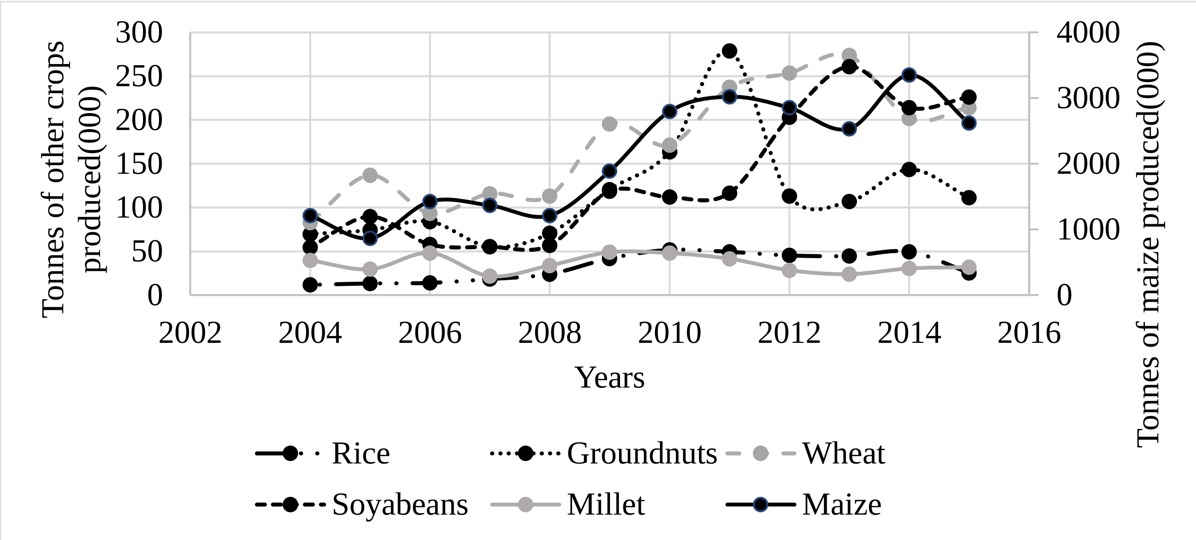

Figure 3.2: The trend of production of crops between 2004 and 2015

Source: (MoA and MoFL, 2016).

The increase in crop production between 2004 and 2015 could be attributed but not limited to two reasons. Firstly, the growth of the population during this period could have played a significant role in increasing crop production, as argued by Fróna *et al.* (2019). The second reason for the increased crop quantity could be due to the increased funding to the Farmer Input Support Programme (FISP). As shown in Figure 3.3, the increased maize production between 2004 and 2011 corresponded with the increased budgetary allocation to FISP from US$ 28.7 million in 2004 to US$ 180.53 million in 2011. Conversely, between 2011 and 2013, the budgetary allocation to FISP reduced from US$ 180.53 million to US$ 92.97 million, which also corresponded to the reduction in maize production shown in Figure 3.3. The relationship observed between maize production and the FISP budget was consistent with studies that showed that FISP had a positive effect on maize produced and incomes generated (Alavo *et al.,* 2019; Funsani *et al.,* 2016; Mason *et al.,* 2013).

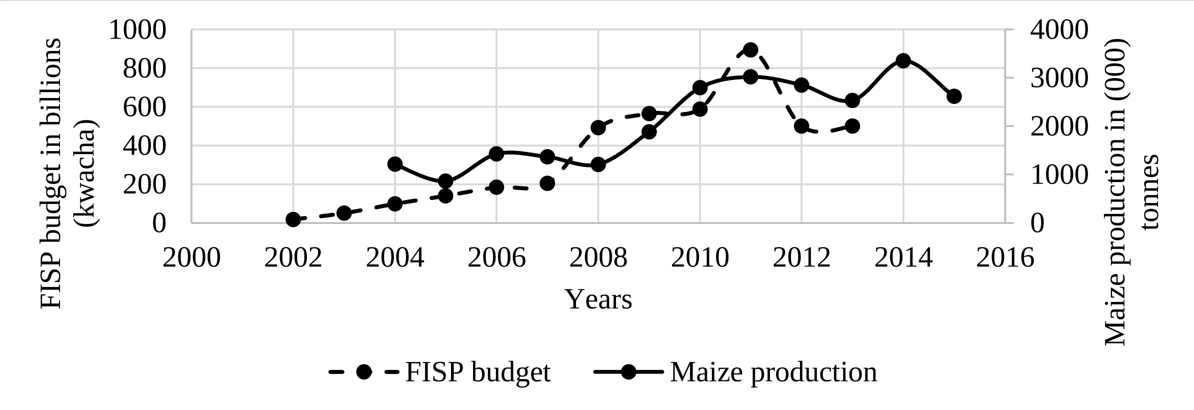

Figure 3.3: Relationship between FISP budget and maize production

Source: (Mason *et al.,* 2013; MoA and MoFL, 2016).
Note: adjusting for inflation does not change the trend/ pattern observed in the graph.

As much of the country's maize production is rain-fed, harvests are affected by rainfall. Figure 3.2 illustrated that 2006 had increased production of maize while the years 2005, 2013 and 2015 had reduced maize production. The year 2006 had high rainfall, while the years 2005, 2013 and 2015 were drier (Libanda *et al.,* 2020). In 2019, Zambia experienced one of the most severe droughts, leading to a 16 percent reduction in maize production compared to the 2018 harvest (Caritas, 2020; Hivos, 2019). Figure 3.2 shows that groundnut production also followed a similar pattern for maize by reducing in drier years while increasing in years with increased rainfall.

Despite the increased quantities of most crops, Zambia's crop sector has been dominated by maize production (Chapoto *et al.,* 2015, 2016). As a result, crop diversity has been low among farmers (Mofya-Mukuka and Hichaambwa, 2016). A panel data analysis of about 8000 Zambian households showed that in 2016, about 80 percent of the sampled smallholder farmers grew three or fewer crops (Mofya-Mukuka and Hichaambwa, 2016). In their analysis, Mofya-Mukuka and Hichaambwa (2016) observed that increasing Food Reserve Agency (FRA) maize purchases and distributing the subsidised fertiliser through the FISP reduced crop diversity in Zambia. Figure 3.4 below illustrates crop diversification in Zambia, with the quantity of maize produced exceeding the combined quantities produced for groundnuts, millet, rice, soybeans, sunflower and wheat.

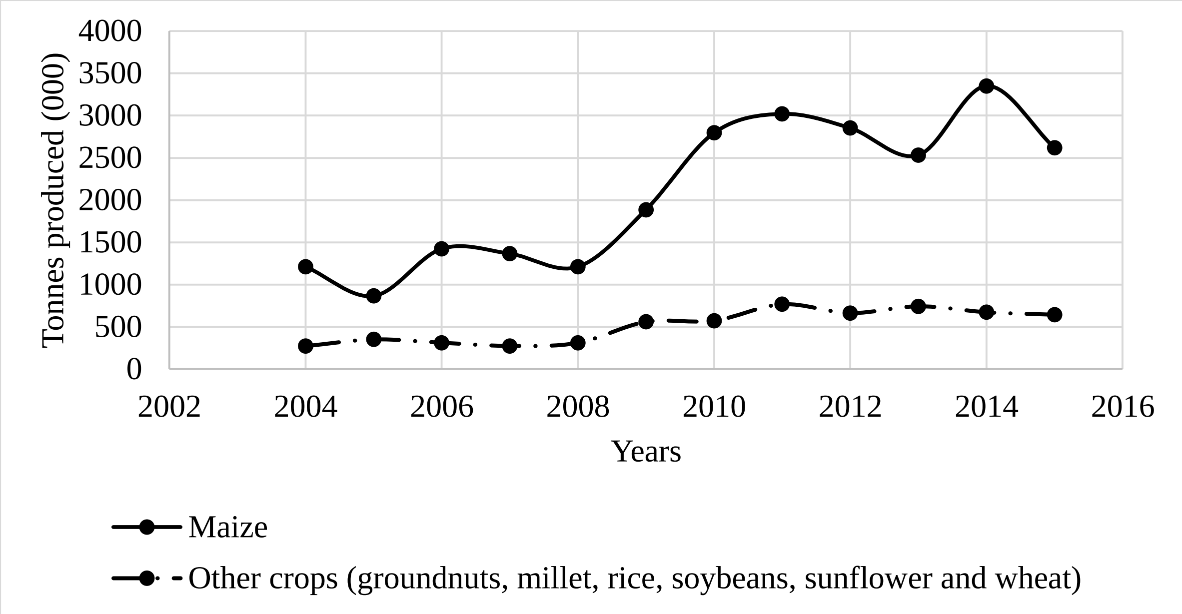

Figure 3.4: The trend of crop production (maize dominance)

Source: (MoA and MoFL, 2016).

MoFL reported production increases in cattle, fish, goats, pigs, poultry and sheep between 2006 and 2014, as shown in Figure 3.5 below (MoA and MoFL, 2016). The increased production of livestock over the period could be due to the increased demand for livestock products driven by population growth, incomes, GDP and urbanisation (Harris *et al.*, 2019; Thornton, 2010).

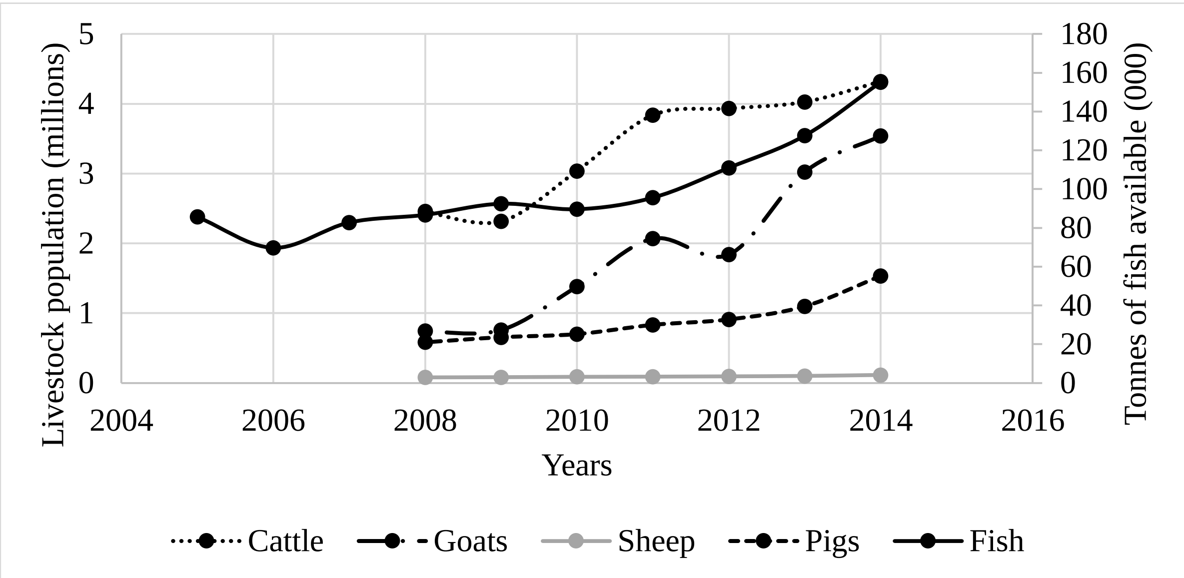

Figure 3.5: Population of livestock and quantity of fish available in Zambia between 2005 and 2014

Source: (MoA and MoFL, 2016).

However, the World Bank reported that although livestock production was growing, Zambia's livestock sector's growth rate was slower than that for Kenya, South Africa and Zimbabwe (The World Bank, 2011). With its grazing area of about 20.3 million hectares, Zambia could increase its cattle population from 3.7 million cattle currently to above 6 million cattle (CSO, 2019; The World Bank, 2011). Other than cattle, Zambia could increase small livestock production by providing access to veterinary, credit and extension services to smallholder farmers (Chipasha *et al.*, 2017).

Regarding the quality of food, the supply of protein in Zambia has increased since 2002, as shown in Figure 3.6. According to the INDDEX Project (2018), the average supply of protein at the national level offers insight into the nutritional quality of food supply. Therefore, the increased supply of protein from 2002 shown in Figure 3.6 below suggested that the nutritional quality of foods available to Zambians has slowly improved over the years (INDDEX Project 2018).

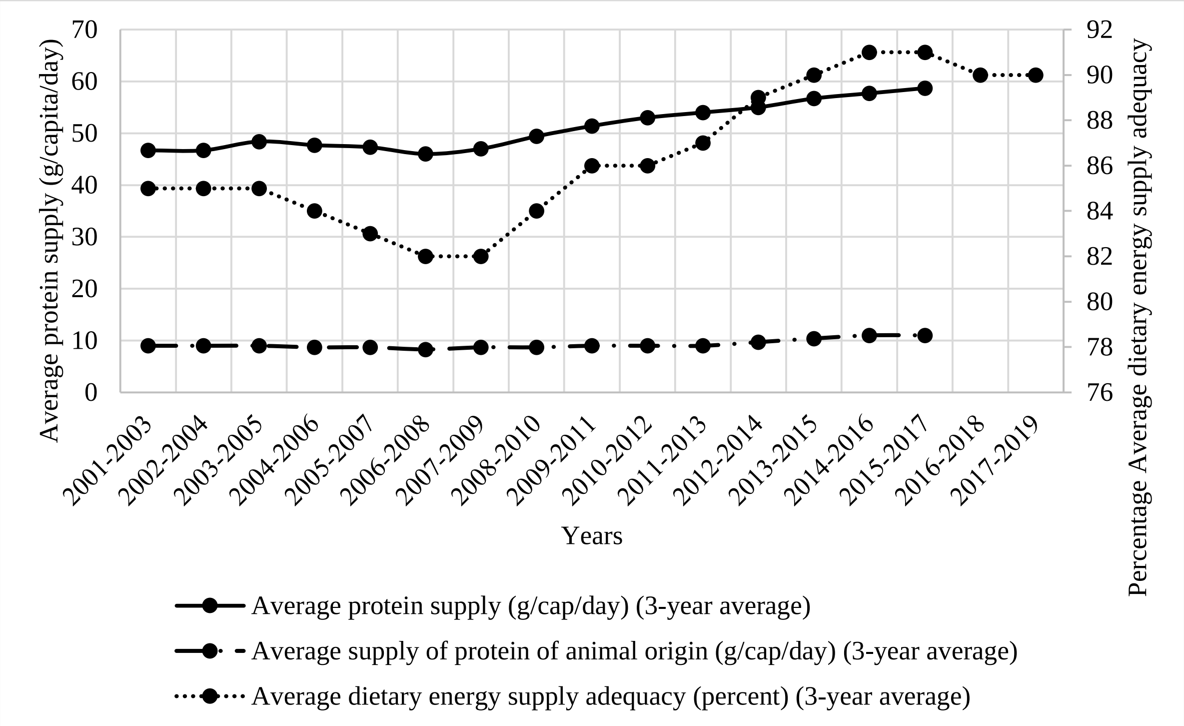

Figure 3.6: Average supplies of animal protein and dietary energy in Zambia

Source: FAOSTAT.

However, Figure 3.6 shows a wide gap between the average supply of protein and the average supply of animal protein, illustrating that Zambia obtained much of her protein from plant sources. This could have affected the quality of nutrition as animal source foods are said to have better protein than foods obtained from plants (Hertzler *et al.*, 2020; Kaimila *et al.*, 2019). Furthermore, although the supply of protein increased between 2001 and 2017, the graph shows that the growth rate was low. The slow growth rate of protein supply could be because cereals dominate Zambian diets, including little or no animal source foods (Zhang *et al.*, 2016). This could partially explain Zambia's slow rate of progress against malnutrition of children under five years of age, such as stunting (CSO *et al.*, 2019; CSO *et al.*, 2015; Dasi *et al.*, 2019).

3.3 Household access to food in Zambia

Access to food refers to the possession or ability to acquire adequate resources required for a nutritious diet (FAO, 2006). Zambia has shown improvements in most of the indicators of food access from the year 2000 to 2018. The unemployment rate has reduced from 12.93 percent in 2000 to 11.5 percent in 2018 (Plecher, 2020). GDP per capita, as shown in Figure 3.7, has grown from US$1619 in 2000 to US$3521 in 2018.

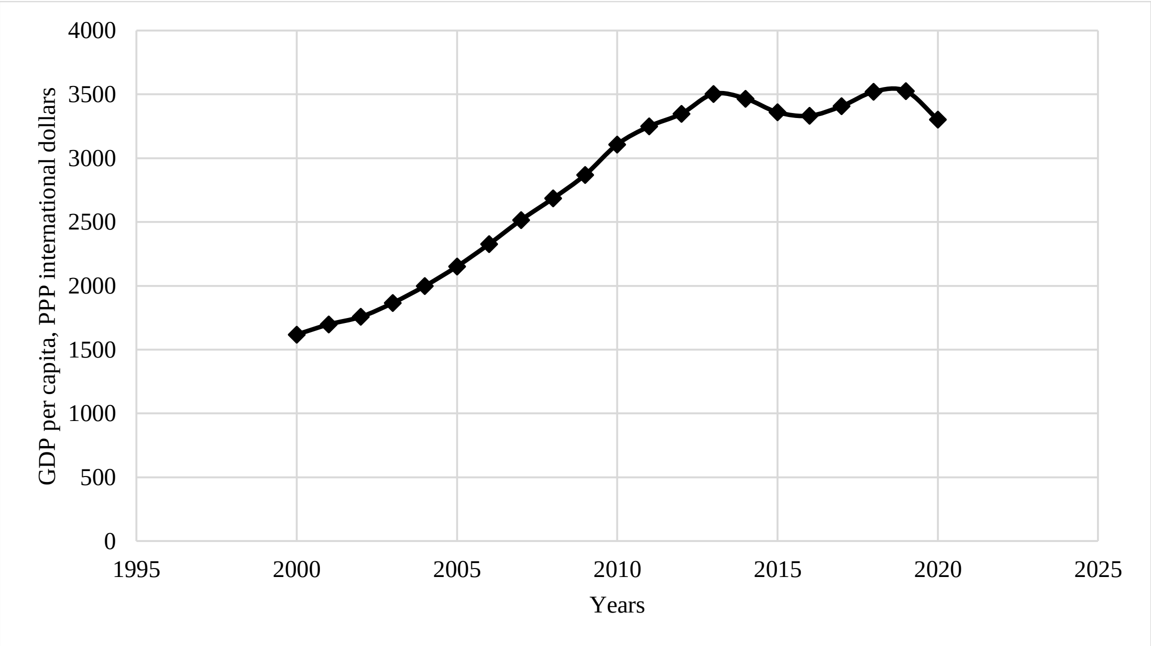

Figure 3.7: Zambia's GDP per capita based on Purchasing Power Parity (PPP)

Source: knoema.com.
Note: adjusting for inflation does not change the trend/ pattern observed in the graph.

Reports from the Living Conditions Monitoring Surveys (LCMS) also showed increases in monthly household incomes between 1998 and 2015 (CSO, 1998; CSO and The World Bank, 2016). As a result, per capita income rose from US$ 13.79 in 1998 to US$ 59.78 in 2015 (CSO, 1998; CSO and The World Bank, 2016). These increments saw average household expenditure on food rise from US$ 27.21 in 1998 to US$ 86.81 in 2015 (CSO, 1998; CSO and The World Bank, 2016). Harris *et al.* (2019) argued that the rise in incomes during this period, coupled with increased GDP, urbanisation and the supermarket industry's growth, led to the changes in the dietary patterns of Zambians. One significant change was the reduction in expenditure on starchy foods but increased spending on animal source foods, fats, fruits, oils, processed foods, sugars and vegetables (Harris *et al.*, 2019). The changes were in line with Bennet's law which stated that when incomes increased, households switched from starchy dominated diets to diets comprising meats, fruit, dairy products, vegetables and other foods (Godfray, 2011).

However, despite these overall improvements in food access indicators in the period discussed above, food access has reduced in the last few years that Zambia has experienced economic challenges. In the first place, the 2015 report of 54.4 percent of Zambians being poor because they lived below the poverty line suggested that over half of the population had challenges accessing nutritious food needed for a healthy lifestyle (CSO, 2016). Moreover, the 2015 level of poverty was higher in rural areas, where 76.6 percent lived below the poverty line compared to 23.4 percent for urban residents (CSO, 2016). The Western province recorded the highest poverty rate (82.2 percent), while Lusaka province recorded the lowest poverty rate (20.2 percent), as shown in Figure 3.8.

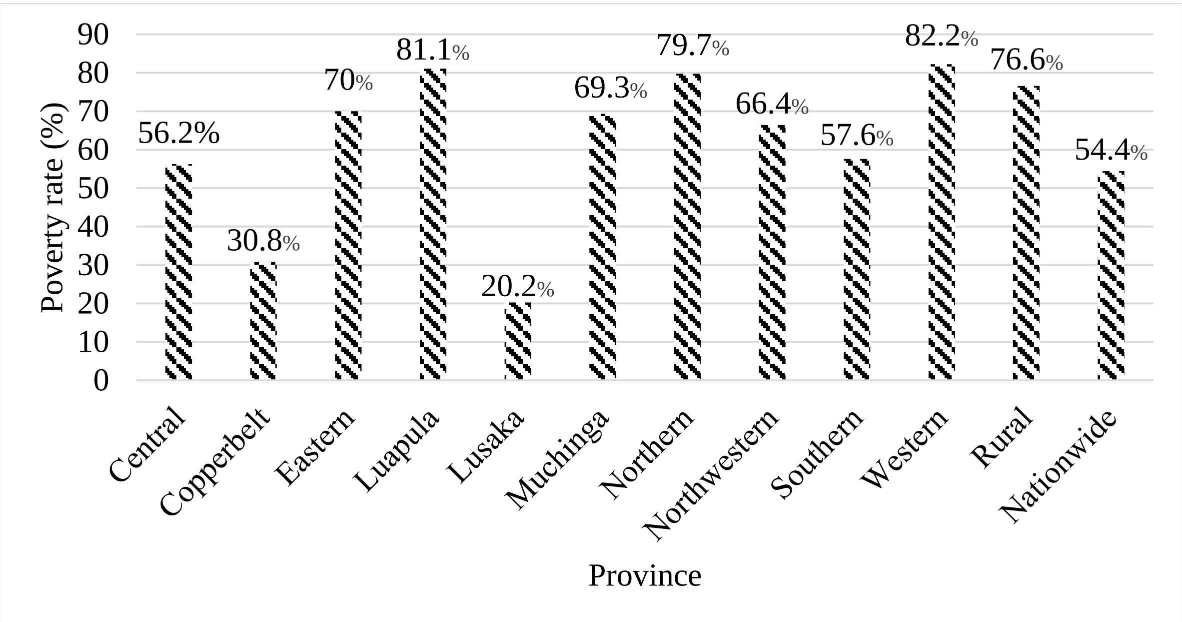

Figure 3.8: 2015 prevalence of poverty residence

Source: (CSO and the World Bank, 2016)

Between 2018 and 2019, the country's staple maize prices rose by about 50 to 70 percent, reducing household purchasing power (Giews-FAO, 2019). The government responded to this steep rise in prices in 2019 by imposing an export ban and a price ceiling to stabilise the prices of maize and its products (Giews-FAO, 2019). In 2020, GDP contracted by 4.9 percent, primarily because key sectors of the economy such as mining, manufacturing, tourism and service deteriorated and were worsened by the effects of Covid-19 (ADB, 2020). The contraction of the economy affected access to food. Meanwhile, annual food inflation rose over the period, with 27.8 percent reported in March 2021 (ZamStats, 2021), as shown in Figure 3.9 below. The Northern Province, one of the provinces with high poverty levels, had an alarming inflation rate of 35.8 percent in March 2021 (ZamStats, 2021).

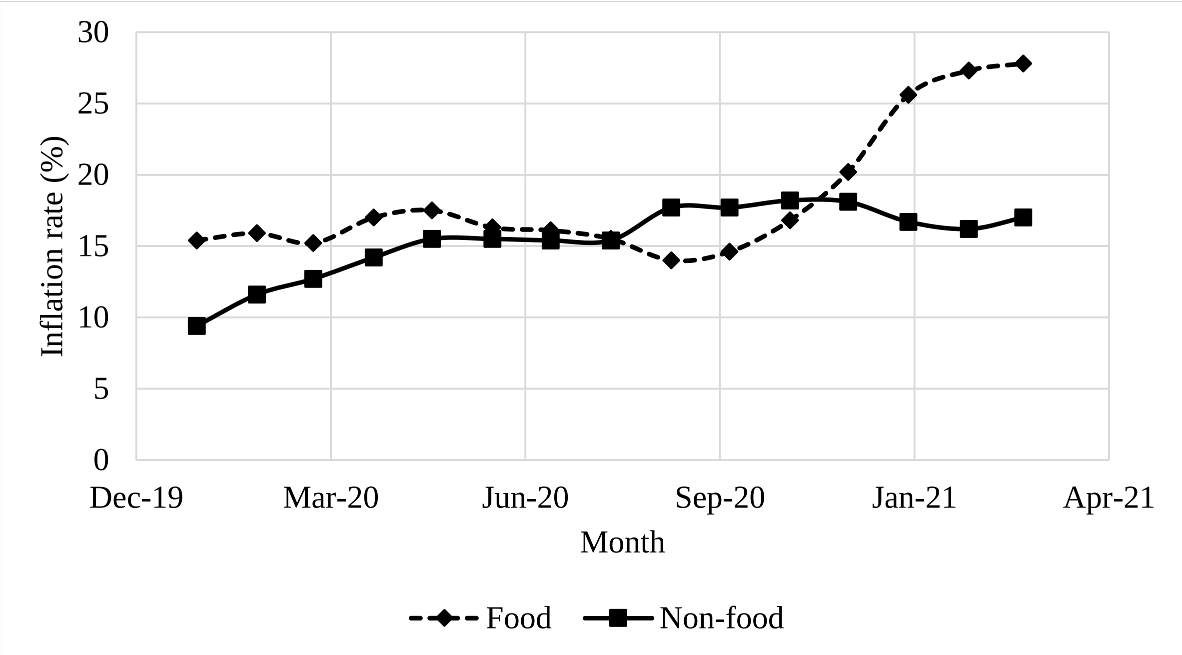

Figure 3.9: Annual food and non-food inflation rate in Zambia

Source: (ZamStats 2021).

The depreciation of the kwacha also suggested a fall in the real value of households incomes. Between September 2019 and September 2020, the kwacha depreciated by 49 percent against the US dollar (Manchishi, 2020). The fall in the value of the Zambian kwacha was an important driver of household food insecurity (FAO *et al.,* 2019). Currency depreciation, combined with the rise in food staff prices, justified reports that 48 percent of Zambians in 2019 could not afford their minimum daily caloric requirement of 2100 kilocalories (Harris *et al.,* 2019; WFP, 2020). Other reports showed that 84.1 percent of Zambians could not afford a healthy diet valued at US$ 3.38 per capita (FAO *et al.*, 2020). The cost of a healthy diet was determined using food-based dietary guidelines and comprised foods from different groups with greater diversity in each group (FAO *et al.*, 2020).

In 2019, the US. Department of Agriculture (USDA) reported that about 61 percent of Zambia's total population was food insecure (Thome *et al.*, 2019). Equally, the Global Hunger Index (GHI) has found Zambia among countries with high food insecurity. In 2018 and 2019, the GHI ranked Zambia as the fifth most food insecure country out of the 119 and 117 countries ranked, respectively (Grebmer *et al.*, 2018, 2019). Figure 3.10 below shows the GHI scores for Zambia for the selected years between 1981 and 2019. The GHI scores trend suggested that Zambia's food security has been borderline between food security or insecurity.

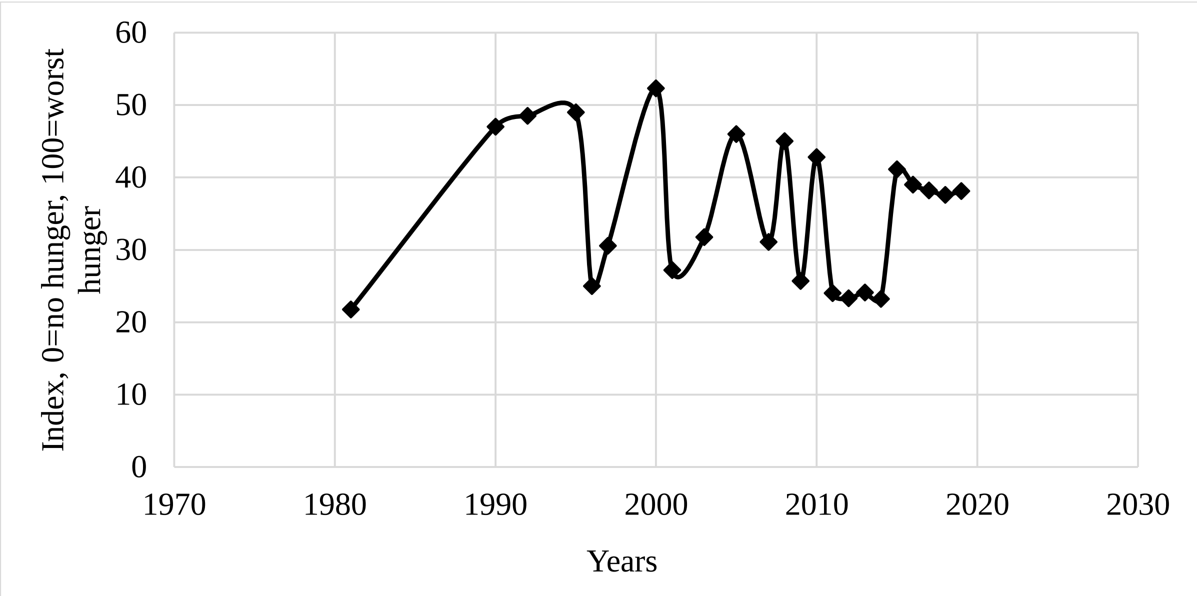

Figure 3.10: Zambia's Global Hunger Index Scores (GHI) between 1981 to 2019

Source: Knoema (2020).

3.4 Food utilisation in Zambia

By definition Food utilization refers to the proper biological use of food by the body, requiring a diet providing sufficient energy and essential nutrients, potable water, and adequate sanitation (USAID, 1998). Poor utilisation of food can result in undernourishment otherwise known as malnutrition in all its forms (Saasi, 2015). Over the years, Zambia has seen an increase in the malnourished population, as shown in Figure 3.11. The increased population of undernourishment could be due to the growth of the population that has put a strain on the country's resources (Hall *et al.*, 2017). Nevertheless, the proportion of undernourishment has slightly reduced since 2005.

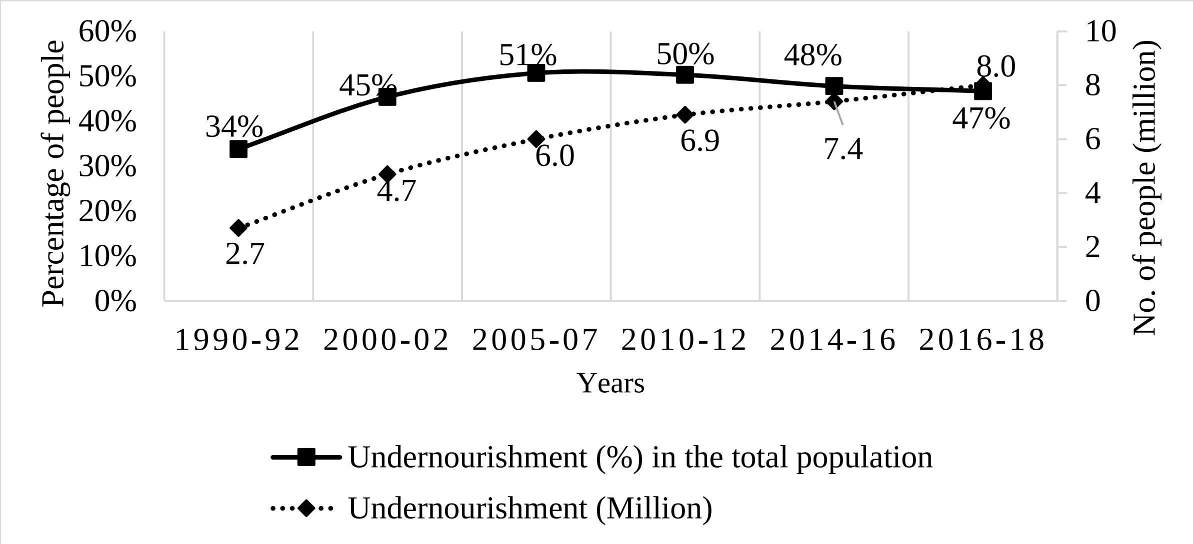

Figure 3.11: Trend of undernourishment in Zambia

Source: FAO *et al.*, (2015), (FAO *et al.*, 2019).

Micronutrient deficiencies are a concern, particularly among women of childbearing age and young children. One of the most critical micronutrient malnutrition cases in Zambia is anaemia in pregnant women and young children. Figure 3.12 shows that although anaemia has reduced since 2000, the rates are still high.

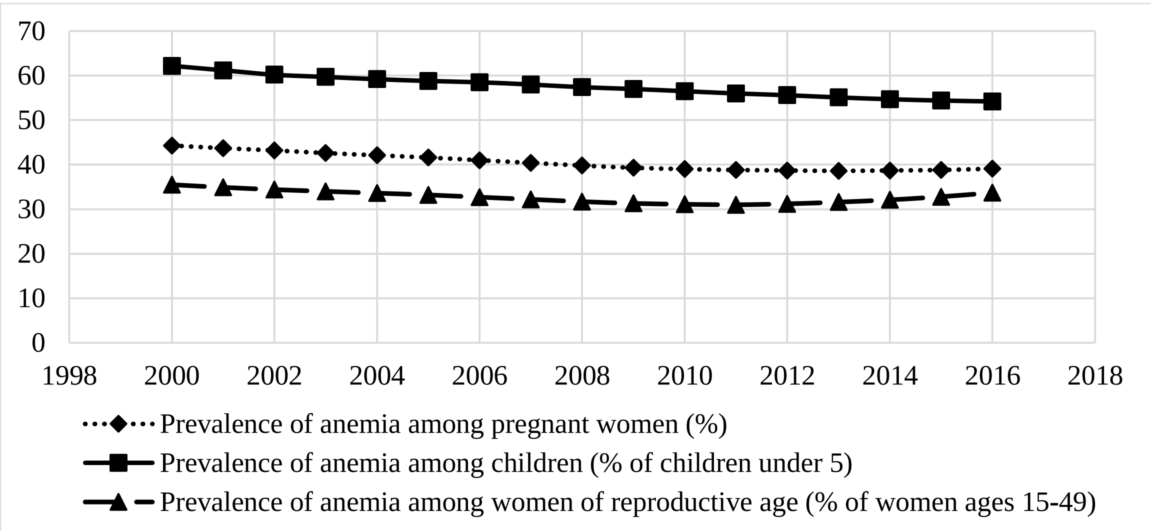

Figure 3.12: Prevalence of anaemia among women of childbearing age and children under five years of age

Source: FAOSTAT.

The 2018 Zambia Demographic Health Survey (ZDHS) reported that the prevalence of anaemia in children under five years was 58.1 percent (CSO *et al.*, 2019). The 2018 ZDHS reported that 31.1 percent of women aged between 15 and 49 were anaemic. Although other factors such as malaria are known risk factors causing anaemia, food insecurity also plays a role (White, 2018). A study in the Mbala district of Zambia observed that some of the factors determining anaemia in children were lack of consumption of iron-rich foods and minimum dietary diversity (Daly *et al.*, 2017).

Zinc and Vitamin A deficiencies are also problematic in Zambia, particularly in women of childbearing age and children under five. A survey conducted by the National Food and Nutrition Commission (NFNC) in Luapula and Northern provinces showed that 55 percent of childbearing age women were deficient in zinc (Alaofe *et al.*, 2014). The survey also showed that 25.8 percent and 22-34 percent of the children under the age of five were zinc and vitamin A deficient, respectively (Alaofe *et al.*, 2014). However, the extent of zinc and vitamin A deficiency in under five years and women of childbearing age countrywide remains unknown.

The prevalence of stunting (height for age), underweight (weight for age) and wasting (weight for height) among children under five years continues to be high in Zambia despite the slow progress recorded in this century. As shown in Figure 3.13, the prevalence of stunting among children under five years stood at 35 percent in 2018. Surprisingly, Lusaka province was among the three provinces with high levels of wasting despite being the economic capital of Zambia (CSO *et al.*, 2019; CSO *et al.*, 2015). The high rates of wasting in the Lusaka province could be due to the higher cases of diarrhoeal diseases such as cholera that Lusaka province experiences (Mwaba *et al.*, 2020). This could be because of a strong association between wasting in children under five years and diarrhoeal cases (Gupta, 2014).

Between 1990 and 2018, stunting among children under five years reduced from 46 percent to 35 percent, underweight reduced from 21 percent to 12 percent, while wasting reduced from 6 percent to 4 percent (CSO, 2015; CSO *et al.*, 2019). The reduction in child malnutrition shown in Figure 3.13 could be because of several factors, including the improvements in household incomes and GDP, particularly in the last two decades (CSO, 2012, 2016; Harris *et al.*, 2019). Nonetheless, the decrease in GDP growth and economic challenges Zambia has experienced in the last few years could imply increased malnutrition of children under five years of age.

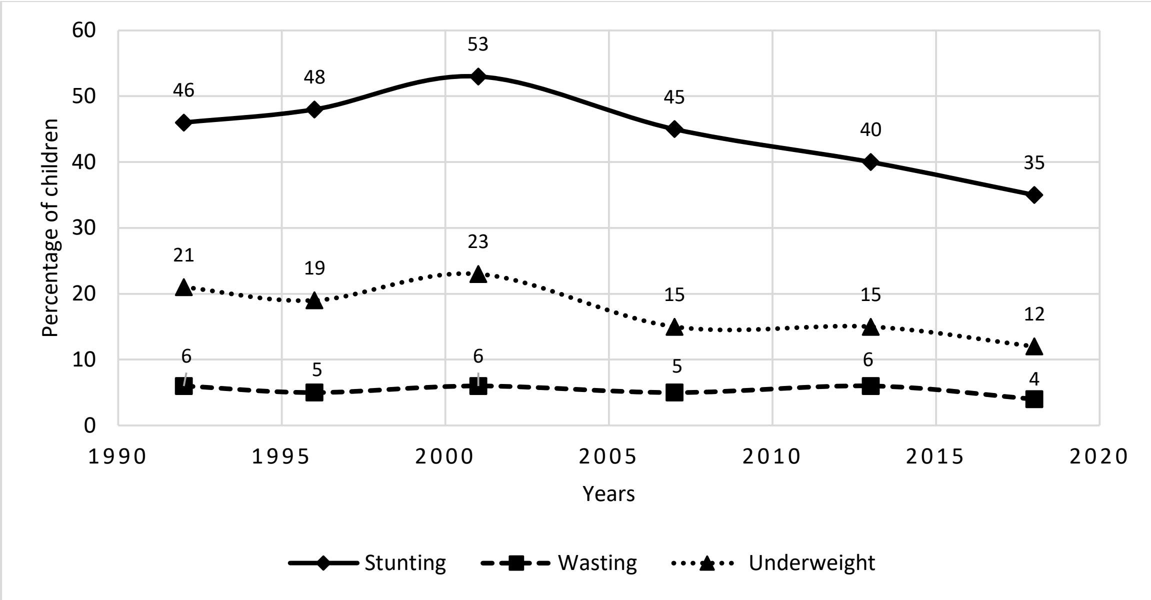

Figure 3.13: Prevalence of stunting, underweight and wasting among children under five years of age in Zambia

Source: ZDHS 2014 and 2018 reports.

CHAPTER 4: METHODS AND PROCEDURES

4.1 Introduction

The overall objective of this study was to determine the effect of the last mile on food security and nutrition in 69 selected districts of Zambia. The methodology adopted is set out in the sections below.

4.2 Data sources and study site

The study used the 2015 Living Conditions Monitoring Survey (LCMS) data collected by the Zambia statistical agency (CSO and The World Bank, 2016). The data was collected from 12,260 non-institutionalised households located both in rural and urban areas. The dataset comprised variables for economic activities, food security, health, income, nutrition and poverty. Agriculture was the main economic activity with 6,392 households growing at least one but not more than 11 crops during the 2014/15 farming season. The LCMS also captured data on monetary expenditure relating to both food and non-food items. During the same time, anthropometric data (height and weight) was collected from 6384 children under the age of five years. Last mile variables included the respondent's estimate of distances and minutes taken to reach a nearest transport facility defined as a paved or feeder road, rail and water transport. Additionally, the dataset included distances and minutes taken to reach the nearest and permanently stationed health centre and market.

The objective of this study required to regress the last mile variables and social economic and demographic variables on food security and nutrition variables. Therefore, rural households were selected from the 69 districts listed in ANNEX A as the population for the study. The study selected 69 out of the 72 districts that existed at the time of the survey to get a nationally representative sample and enjoy the advantages of large sample sizes, such as precise statistical estimates and generalisability of the results (Roessner, 2014). Furthermore, the total number of observations to be considered in the the models will depend on the number of households or children under five years with complete data.

4.3 Models and data analysis

The last mile was measured using a household's distance from a given public facility, i.e. market, health centre and transport facilities such as a road, waterway or railway. These last mile indicators were regressed against household food security and child nutrition outcomes.

4.3.1 Analysing the effects of the last mile variables on household food security

The study measured household food security as calories per capita from crop production, crop diversity and expenditure on non-staple food. These variables were used in order to understand how the last mile variables affected food available from both household production and markets. Crop yield per capita was computed using the two equations shown below. Equation 4.1 calculated the number of calories from each crop using the 4th edition of Zambia's food composition table (NFNC, 2009). Equation 4.2 calculated the per capita dietary energy which was the number of calories available from crop production for each member of the household.

$$Calories\ per\ crop = Quantity\ (kg) * \frac{1000g}{kg} * \frac{Calories}{100g\ edible\ portion} \qquad \text{Equation 4.1}$$

$$Per\ capita\ dietary\ energy\ = \frac{\sum(Cal1+Cal2+Cal3+\cdots+Caln)}{Household\ size} \qquad \text{Equation 4.2}$$

Where Cal1 + Cal2 + Cal3 + … + Caln is a summation of the calories calculated for crops 1, 2, 3, …, n.

Table 4.1 below shows the edible portion per 100 grams of each crop produced by a given household. The edible portions were based on the fourth edition of Zambia's food composition table (NFNC, 2009).

Table 4.1: Edible portion of each crop produced according to the fourth edition of Zambia's food composition table

Crop	Description	Edible dietary energy (calories) per 100 grams
Maize	shelled, white whole	366
Cassava	Tuber	342
Finger Millet	threshed, whole	348
Sorghum	Whole	359
Rice	Undermilled	353
Mixed beans	shelled, Kabulangeti	315
Soya beans	Shelled, (Fresh)	373
Sweet potatoes	Tuber	114
Irish potatoes	Tuber	75
Groundnuts	Shelled, Makulu Red Groundnuts	547

Source: (NFNC, 2009).

Crop diversity was measured using the Crop Diversity Index (CDI) as per the procedure set out by Sichoongwe *et al.* (2014). CDI was computed using Equation 4.3, Equation 4.4 and Equation 4.5.

$P_i = \frac{A_i}{\sum A_i}$ Equation 4.3

Where:

P_i was the proportion of the ith crop

A_i was the area in hectares covered by the ith crop

$\sum A_i$ was the total cropped area

I=1, 2, 3, 4,..,nth crop

$HI = \sum P_i^2$ (Herfindahl Index) Equation 4.4

$CDI = 1 - HI$ (Crop diversification index) Equation 4.5

The stepwise regression was used to regress dependent variables on independent variables selected from the literature reviewed. The study used three stepwise regression strategies, i.e. backward, forward and stepwise selections (Bruce and Bruce, 2017; James *et al.*, 2013). The best set of independent variables that explained food security and nutrition indicators were chosen based on the smallest AIC value. These independent variables are listed in Table 4.2

below as defined in ANNEX B.

Table 4.2: Independent variables of the study

Predictor	Type	Level	Expected sign
Adult labour ration (AdtLbR)	Continuous	Household	+
Asset value (US$)	Continuous	Household	+
Child age in months (ChldAg)	Continuous	Child	-
Child lives with biological mum (Chldliv) (yes=1)	Dummy	Child	+
Child relationship to household head (Chld2HH) (own child=1)	Dummy	Child	+
Child's sex (Chldsx) (male=1)	Dummy	Child	+/-
Crop Diversity Index (CDI)	Continuous	Household	+
Dependency ratio (DepRatio)	Continuous	Household	+
Farm input expenditure (CrpEx)	Continuous	Household	+
Hectares cultivated (Hctr)	Continuous	Household	+
Household head age	Continuous	Household	+
Household head education level (HHEdu)	Continuous	Household	+
Household head married (HHMar)	Continuous	Household	+
Household head employed in agric. Sector (HHAg) (yes=1)	Dummy	Household	+
Household head formally employed (HHFrml) (yes=1)	Dummy	Household	+
The household head was disabled (Disab) (yes=1)	Dummy	Household	-
Household head self-employed (HHSelf) (yes=1)	Dummy	Household	+
Household head sex (HHSx) (male=1)	Dummy	Household	+/-
Household size (HHSize)	Continuous	Household	+/-
Household sold crop (HHSold) (yes=1)	Dummy	Household	+
Kilometres to a food market (Foodmkt)	Continuous	Household	-
Kilometres to a health centre (Health)	Continuous	Household	-
Kilometres to a transport facility (Trnsprt)	Continuous	Household	-
Kilometres to farm input market (Inptmkt)	Continuous	Household	-
Maternal age (MumAg)	Continuous	Child	+
Maternal education (MatEdu)	Continuous	Child	+
Non-staple expenditure (Nonstpl)	Continuous	Household	+
Per capita dietary energy (Kcalpcap)	Continuous	Household	+
Per capita income (pCapInc)	Continuous	Household	+
Per capita expenditure (US.) (PCapEx)	Continuous	Household	+
Poverty status (Poor) (poor=1)	Dummy	Household	-
Total monthly income (Totalinc)	Continuous	Household	+

The study employed Ordinary Least Squares (OLS) regressions to analyse calories per capita from crop production and non-staple food expenditure. The two models were specified as given in Equation 4.6 and Equation 4.7. (for abbreviations, see Table 4.2 above). Expenditure on non-staple foods was estimated as:

$$Nonstpl \sim Inptmkt + Trnsprt + Poor + CDI + HHAgric + HHSize + Totalinc + Asset + DepRatio \quad \text{Equation 4.6}$$

Calories per capita from crop production was estimated as:

$$lKcalpcap \sim CrpEx + HHSize + Hctr + HHSold + PCapInc + AdtLbR + HHAgric + Health + HHGrade + HHDisab + Copperbelt + Western + Northern + Luapula + Southern \quad \text{Equation 4.7}$$

The analysis of crop diversity employed the Tobit model because the dependent variable CDI had a significant number of zeros as observations. The Tobit model for crop diversity was specified in Equation 4.8 below.

$$CDI \sim HHAg + HHsx + HHself + HHsize + Inptmkt + Asset + Nonstpl + Central + Copperbelt + Lusaka + Muchinga + Northern + Southern \quad \text{Equation 4.8}$$

4.3.2 Analysing the effects of the last mile on child nutrition

A two-level multilevel model was employed to analyse the effect of the last mile on child nutrition because the variables were measured at two levels, i.e., child and household levels. It was assumed that all error terms were independent and that the effects of independent variables on dependent variables were the same across all districts and households (Roback and Legler, 2021). The general model was specified as follows (Roback and Legler, 2021):

Child-level: $Y_{ij} = \gamma_k + \beta_k H_{ij} + \mu_{ij}$ Equation 4.9

Household-level:

$$\gamma_j = \gamma_0 + \alpha_1 D_j + u_j \quad \text{Equation 4.10}$$

$$\beta_j = \beta_0 \quad \text{Equation 4.11.}$$

where:

- Y_{ij} was the Z-score (HAZ or WAZ scores) of the i^{th} child in the j^{th} household
- H_{ij} was the child-level variable, e.g. age, sex, etc., while D_j was the household level variable, e.g. poverty status, distance to the food market, etc.

The study used Height-for-Age Z-scores (stunting or HAZ), Body Mass Index (BMI) for Z-scores (thinness or BAZ), Weight-for-height Z-scores (wasting or WHZ) and Weight-for-Age

Z-scores (underweight or WAZ) to determine the last mile's effect on child nutrition. Child nutrition outcomes were used because they indicate the level of nutrition for household members. The models HAZ (Equation 4.12), WAZ (Equation 4.13), BAZ (Equation 4.14) and WHZ (Equation 4.15) were specified below.

$$\text{HAZ} \sim \text{Foodmkt} + \text{ChldAg} + \text{MumAg} + \text{MatEdu} + Totalinc + \text{HHEdu} + HHSize + \text{Central} + \text{Copperbelt} + \text{Lusaka} + \text{Southern} + (1|\text{HHN}) \quad \text{Equation 4.12}$$

$$WAZ \sim ChldAg + Kcalpcap + Foodmkt + Chld2HH + HHFrml + Chldsx + Central + Western + Hctr + Southern + HHAg + CDI + Northern + (1|HHN) \quad \text{Equation 4.13}$$

$$BAZ \sim Central + \text{Nonstpl} + \text{Chldliv} + Lusaka + \text{MatEdu} + Northern + Copperbelt + Western + \text{HHMar} + (1|HHN) \quad \text{Equation 4.14}$$

$$WHZ \sim \text{Chldsx} + \text{MumAg} + \text{Chldliv} + \text{pCapEx} + \text{HHEdu} + Hectares + \text{Kcalpcap} + Central + Lusaka + (1|HHN) \quad \text{Equation 4.15}$$

Note: (1|HHN) refers to the clustering at the household level.

4.4 Missing data, outliers and diagnostic tests of the regression assumptions

Missing data was corrected by excluding the households that did not have complete data. The consequences of missing data include reducing the study's statistical power and biased estimates (Kang, 2013). Thus, it was important to sort missing data before analysis. After handling missing data, the selected variables were corrected for outliers using log transformation and winsorisation methods (Cousineau and Chartier, 2011; Signorell, 2021). These methods were selected over the other methods, such as deletion, to avoid loss of observations and maintain the statistical power of the analysis (Kang, 2013).

Diagnostic tests of regression assumptions were carried out to ensure that the estimates of the regressions were reliable. To achieve this, the assumption of no multicollinearity needed to be tested using the Variance Inflation Factors (VIFs). The absence of multicollinearity meant the lack of linear relationships among independent variables. A VIF value greater than five was evidence of the presence of significant multicollinearity (Glen, 2020). The solution to multicollinearity was the exclusion of some of the variables that had a strong linear relationship.

Another assumption that needed to hold was that the variance of the error term was constant (homoskedasticity) given the independent variables (Wooldridge, 2015). The violation of this assumption would indicate heteroskedasticity, which was tested using the Breush-Pagan test for OLS and Levene's test for multilevel models (Palmeri, 2020; Wooldridge, 2015). Robust standard errors were employed in heteroskedastic models to account for heteroskedasticity (Yobero 2016). The use of robust standard errors corrected the variance of the error term, which is not constant in the presence of heteroskedasticity (Zorn, 2006).

Furthermore, the models' residuals should have a normal distribution to avoid the false rejection of the null hypotheses (Knief and Forstmeier, 2021). The Q-Q plot method was used to carry out this test (Palmeri, 2020). The residuals follow a normal distribution if the overall plotted line does not deviate from the straight dotted line in the Q-Q plot. However, if this assumption is violated, the dependent variable will be transformed using a logarithm in order to have residuals with a normal distribution (Palmeri, 2020).

This analysis was carried out using the R statistical package. In addition, the World Health Organisation (WHO) nutrition software, anthro, was used to calculate the child nutrition outcomes. The following chapters set out the results and discussion for the two sub-objectives.

CHAPTER 5: THE EFFECT OF THE LAST MILE ON FOOD SECURITY

This chapter presents the results answering the study's first objective that sought to determine the effect of the last mile on household food security. The first section of this chapter discusses the statistics related to the proximity of households to public facilities. In contrast, the second section presents and discusses the results of the diagnostic tests of regression assumptions and the goodness of model fit. The outputs of the models are discussed in the third section, while the last section presents the summary of results and the study hypothesis.

5.1 Household distances from public facilities

Households in the sample were generally far from transport facilities, markets and health centres. On average, the nearest facility was the transport facility, while the furthest was the farm input market, as presented in Table 5.1 below.

Table 5.1: Household access to public facilities

Public facility	Mean distance from household (km)	Proportion (%) of households taking more than 30 minutes to access the facility
Health centres	6.53	65.5
Food markets	10.77	63.3
Farm input market	24.1	78.4
Transport facility	3.71	41.2

Source: Author's analysis of CSO data (LCMS, 2015).

These statistics suggested that most households were in the last mile since they were beyond the recommended radii of two kilometres or 30 minutes away from public facilities (The World Bank, 2016). Consistent with the 2015 LCMS report, a larger proportion (78.4 percent) of households in the sample took more than 30 minutes to reach a farm input market, suggesting that households had challenges accessing inputs for farming activities.

5.2 Model fit and results for diagnostic tests for regressions assumptions

The study ran three models to analyse the last mile's effect on household food security. These models were: calories per capita from crop production, crop diversity and expenditure on non-staple foods. Before interpreting the outputs from these models, the study ran diagnostic tests to check the goodness of the model fit and determine whether the key regression assumptions held.

The analysis found that the models gained a better fit with the addition of predictor variables. For example, the log-likelihood (LL) test found that a full crop diversity model had a value of -468.59 compared to -573.49 for the null model. The LL test generated a significant p-value confirming that the full model had a significantly better fit than the null model. Similarly, the models for the household expenditure on non-staple foods and calories per capita from crop production had a good fit with R^2 of 0.78 and 0.56, respectively. The high R^2 values suggested that the independent variables explained a large proportion of the variation in the dependent variable.

The Breush-Pagan test found no heteroskedasticity in the calories per capita model. However, the test found that the models for crop diversity and expenditure on non-staple foods were heteroskedastic. This finding meant that the variances of the error terms were not constant in the two models. Heteroskedasticity in the crop diversity and expenditure on non-staple foods models were corrected using robust standard errors (Yobero, 2016).

The Q-Q plots generated found that the residuals for the calories per capita model did not follow a normal distribution. Figure 5.1 below shows that a line plotted significantly deviated from the straight line dotted in the graph. This was evidence of the violation of the assumption of normal distribution of the model residuals. The violation of this assumption was corrected by the log transformation of the dependent variable, i.e. per capita dietary energy.

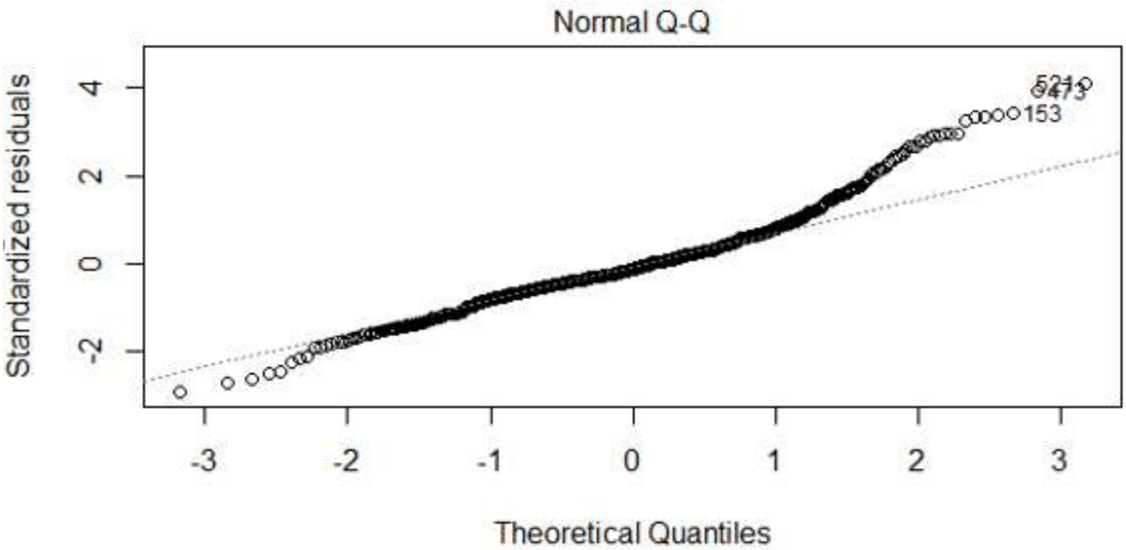

Figure 5.1: Q-Q plot for the calories per capita model (kcalories per capita)

Source: Author’s analysis of CSO data (LCMS, 2015).

On the other hand, the line plotted in Figure 5.2 did not significantly deviate from the straight line dotted in the graph. This implied that residuals followed a normal distribution after the log transformation of the dependent variable (kcalories per capita).

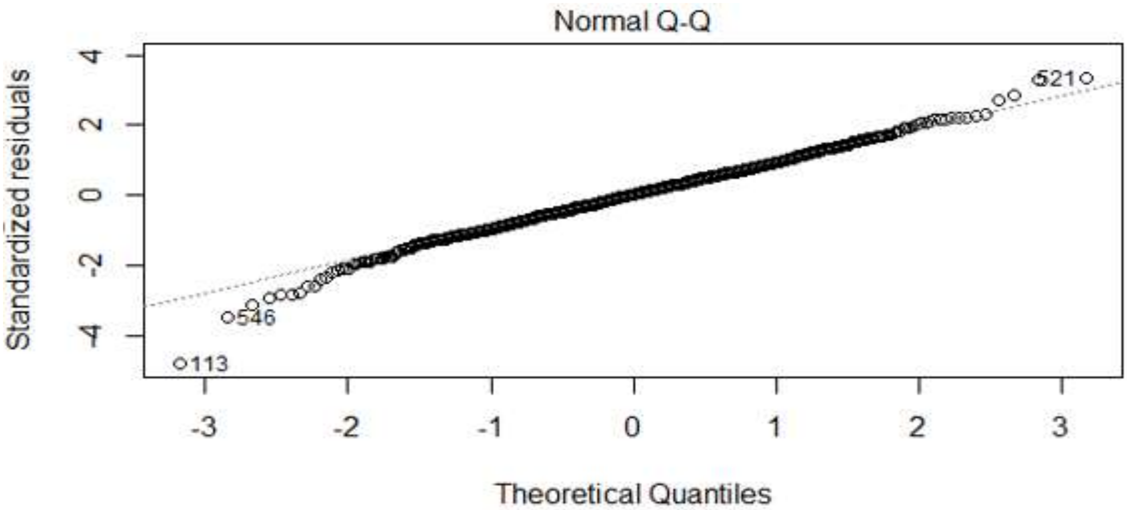

Figure 5.2: Q-Q plot for the calories per capita model after log transformation of dep. variable

Source: Author's analysis of CSO data (LCMS, 2015).

The model for expenditure on non-staple food did not violate the assumption of normal distribution of residuals. Figure 5.3 below showed the plotted line aligning with the dotted line in the graph, although there was deviation at the tails.

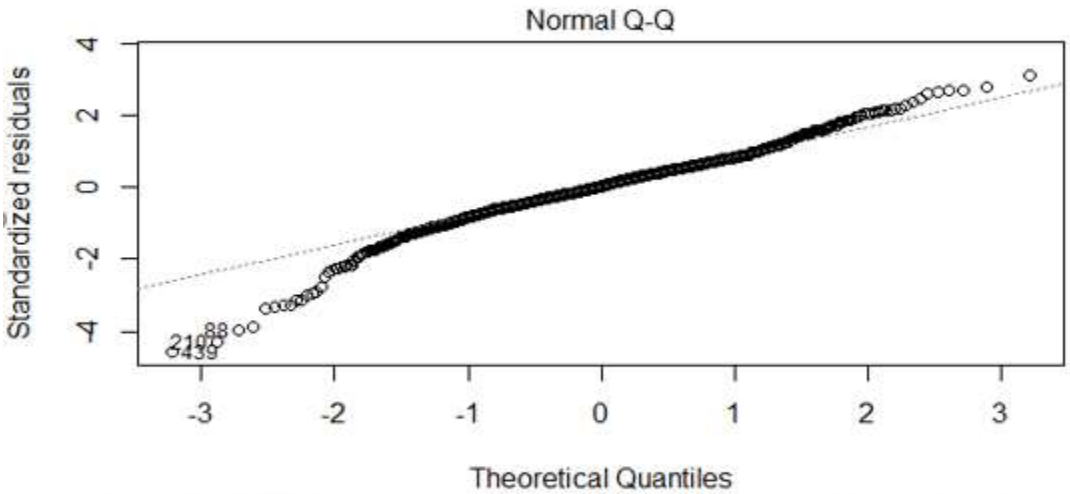

Figure 5.3: Q-Q plot for expenditure on non-staple food model

Source: Author's analysis of CSO data (LCMS, 2015).

Meanwhile, the test for multicollinearity showed that all the variables in the respective models were not linearly related. The VIF values given in

Table 5.2 below were all less than five, implying no linear relationship among independent variables in the models.

Table 5.2: Results for the test for multicollinearity - Variance Inflation Factors (VIFs)

Predictor	**Calories per capita from crop production**	**Non-staple foods**	**Crop diversity**
Adult labour ratio	1.38		
Asset value (US$)		1.63	1.39
Dependency ratio		1.38	
Farm input expenditure (US$)	2.17		
Hectares cultivated cultivated	2.01		
H. head age			1.12
H. head self-employed (1=yes)			1.09
H. head sex (1=male)			1.09
Household size	1.57	2.34	1.23
Household sold crop (1=yes)	1.15		
H. head employed in agric. sector (1=yes)		1.05	
Kilometres to a food market	1.21		
Kilometres to farm input market		1.08	1.07
Kilometres to health	1.15		
Kilometres to transport facility		1.10	
Non-staple expenditure (US$)			1.44
Per capita income (US$)	1.47		
Poverty status (1=yes)		2.39	
Total monthly income (US$)		3.35	
Central			1.21
Copperbelt			1.30
Lusaka	1.05		1.17
Muchinga	1.08		1.16
Northern			1.11
Northwestern	1.03		
Southern			1.22

Source: Author's analysis of CSO data (LCMS, 2015).

5.3 Discussion of the results of the descriptive statistics and regression outputs

The analysis of the effect of the last mile on calories per capita from crop production, crop diversity and household expenditure on non-staple foods considered 1254 households. However, for each regression, households that had missing data on some of the variables of interest were excluded from the analysis. For this reason, 665 households, 1159 households and 765 Households were analysed in the calories per capita, crop diversity and expenditure on non-staple food models, respectively.

The most common livelihood activity among the sampled households was agriculture, with 93 percent of the households growing at least one crop. The sampled households grew different crops, including beans, cassava, groundnuts, Irish potatoes, maize, millet, pineapples, rice, sorghum, soybeans and sweet potatoes. Nonetheless, maize production was the primary crop and source of dietary energy. The data presented in Table 5.3 shows that maize alone contributed 86.6 percent of the total dietary energy produced by the sample households. The second most important source of dietary energy was groundnut production which contributed about eight percent of the total dietary energy produced in the sample, as shown in Table 5.3 below.

Table 5.3: Dietary energy contribution by each crop produced

Crop	**The proportion of dietary energy produced (%)**	**Per capita energy production (kcal per capita)**
Maize	86.58	2505.37
Cassava	1.76	50.8
Millet	0.5	14.59
Sorghum	0.13	3.67
Sweet potatoes	1.28	36.92
Beans	0.54	15.73
Irish potatoes	0.07	2.16
Groundnuts	7.96	230.42
Soya beans	1.04	30.12
Rice	0.13	3.85

Source: Author's analysis of CSO data (LCMS, 2015).

Sampled households from the Central, Eastern and Southern provinces obtained much of their dietary energy from groundnut, maize and soya bean production. On the other hand, households sampled from the Luapula, Muchinga, Northern and North-Western provinces obtained much of their dietary energy from beans, cassava, millet and rice production. Table 5.4 shows that households from different provinces depended on different crops as sources of dietary energy.

Table 5.4: Proportion (%) of dietary energy contributed by each crop in the ten provinces

Province	Maize	Cassava	Millet	Sorghum	Sweet potat.	Mixed beans	Irish potat.	G/nuts	Soy beans	Rice
Central	33.54	0	0	15.83	13.46	0.84	0.89	54.48	44.21	0
Copperbelt	15.9	0.2	1.1	4.33	31.31	16.65	0	5.24	10.57	0
Eastern	11.2	4.02	0	1.7	7.33	5.31	57.54	16.44	27.12	5.9
Luapula	0.76	18.6	3.98	1.31	2.11	3.62	0	1.81	0	0
Lusaka	3.29	2.51	0	0	1.82	0	0	1.27	0	0
Muchinga	10.2	29.04	24.5	10.84	19.01	25.01	9.62	4.36	0.38	55.13
Northern	2.28	17.16	65.26	0	2.65	25.2	1.22	2.29	2.14	1.48
N.Western	1.49	14.19	0	0	1.32	16.28	0	3.19	0	0
Southern	20.5	0.4	2.58	62.6	19.45	7.09	30.73	9.65	15.58	0
Western	0.84	13.88	2.58	3.39	1.54	0	0	1.27	0	37.49
Total	100	100	100	100	100	100	100	100	100	100

Source: Author's analysis of CSO data (LCMS, 2015).

The differences in the quantities of dietary energy contributed by provinces could be attributed to the different climatic conditions that dictated the crops grown in each province (MoA and MoFL, 2016). For example, the climate in the Central, Eastern and Southern provinces is suitable for crops such as groundnuts, maize and soybeans (MoA and MoFL, 2016). In contrast, the environment in the Luapula, Muchinga, Northern and North-Western provinces is suitable for beans, cassava, millet and rice production (MoA and MoFL, 2016). These differences in the crops grown coupled with policies favouring maize production could justify the higher per capita dietary energy production observed for the Central province as presented in Table 5.5 (Chapoto *et al.*, 2016, 2015; MoA and MoFL, 2016).

Table 5.5: Distribution of calories per capita from crop production by each province in the 2014/15 farming season (N=665 Households)

Province	Average household dietary energy (kilocalories per capita)	The proportion of contribution (%)
Central	5669.88	34.06
Copperbelt	3081.83	14.78
Eastern	2113.15	11.54
Luapula	1082.41	1.2
Lusaka	2901.67	3.01
Muchinga	3148.88	10.3
Northern	2755.79	2.98
North western	2751.22	1.9
Southern	2727.03	19.11
Western	650.38	1.13
Nationwide	2037.91	100

Source: Author's analysis of CSO data (LCMS, 2015).

However, the analysis found that crop diversity was low among the sampled households. About 89 percent of the sampled households grew three or fewer crops, while the most crop diverse household grew eight crops. High crop diversity was observed among households from provinces such as the Luapula, Muchinga and Northern provinces, where maize was not a staple food, as shown in Table 5.6. This result suggested that maize dominance contributed to low crop diversity in Zambia (Chapoto *et al.*, 2015, 2016). More urbanised provinces, such as Lusaka province, had low crop diversity suggesting that households in highly urbanised provinces engaged in off-farm activities.

Table 5.6: Distribution of crop diversity per province for the 2014/2015 farming season (N=1159 households)

Province Province	Average count crop	Maximum crop count	Average CDI	Maximum CDI
Central	2	5	0.16	0.50
Copperbelt	2	5	0.18	0.50
Eastern	2	7	0.29	0.43
Luapula	3	6	0.30	0.50
Lusaka	1	4	0.06	0.49
Muchinga	2	7	0.32	0.50
Northern	3	8	0.33	0.50
North Western	2	4	0.27	0.50
Southern	2	5	0.18	0.50
Western	2	5	0.28	0.50
Nationwide	**2**	**8**	**0.23**	**0.50**

Source: Author’s analysis of CSO data (LCMS, 2015).

Moreover, low poverty levels in Lusaka implied that households could meet their nutritional needs from expenditure on non-staple foods as opposed to crop diversity, as shown in Table 5.7 below. On average, a household spent about US$ 51.99 on non-staple foods. Households sampled from Lusaka province spent the highest proportion of their household budget on non-staple foods. In contrast, households from the Luapula, Northern and Western provinces spent the least budgets on non-staple foods compared to other provinces. The pattern of expenditure observed could be attributed to the levels of poverty reported.

Table 5.7: Household monthly expenditure on non-staple foods by province for May 2015 (N=763 households)

Province	Minimum non-staple Expenditure (US$)	Average non-staple Expenditure (US$)	Maximum non-staple Expenditure (US$)
Central	11.30	62.40	277.92
Copperbelt	9.25	60.67	346.95
Eastern	5.81	57.54	216.25
Luapula	10.31	41.11	97.18
Lusaka	16.94	85.20	263.40
Muchinga	5.21	44.54	217.25
Northern	9.77	32.92	80.67
North Western	8.77	43.85	142.24
Southern	3.92	56.04	295.13
Western	2.00	41.26	264.55
Nationwide	2.00	51.99	346.95

Source: Author's analysis of CSO data (LCMS, 2015).

While Lusaka province had the least poverty rate, the Luapula, Northern and Western provinces were the poorest provinces in the country (CSO and World Bank, 2016). This pattern of expenditure observed was consistent with Bennet's law which stipulated that poor households spent a lower budget on non-staple foods compared to non-poor households (Godfray, 2011).

The regression results showed that some of the last mile variables were statistically related to food security. Households located near food markets produced higher calories per capita from crop production compared to households further away. Although the results suggested that household proximity to food markets increased calories per capita from crop production, there was no significant effect in real terms since the coefficient was small. Proximity to food markets failed to influence calories per capita from crop production because the local markets failed to satisfy the market needs of the surrounding farming households, such as the adequate supply of farm inputs and output market for their crops (Fungo *et al.*, 2017). Similarly, proximity to a health centre did not influence calories per capita from crop production, as shown in Table 5.8. The lack of a significant effect of proximity to a health centre on calories per capita from crop production could be because health centres do not emphasise crop production activities. Instead, they focus on other services such as disease treatment and prevention.

Table 5.8: Regression results for calories per capita from crop production (log per capita dietary energy)

Predictors	Estimates	p
(Intercept)	6.5041***	<0.001
Farm input expenditure	0.0003***	<0.001
Household size	-0.1280***	<0.001
Hectares cultivated	0.1664***	<0.001
Household sold crop (1=yes)	0.5922***	<0.001
Adult labour ratio	0.2688*	0.067
Kilometres to a food market	-0.0072***	0.002
Kilometres to a health centre	0.0062	0.198
Per capita income (US$)	0.0021	0.252
Central (yes=1)	0.2798***	<0.001
Muchinga (yes=1)	0.4469***	<0.001
North Western (yes=1)	0.4749***	0.004
Lusaka	0.3708**	0.013
Observations	665	
R^2 / R^2 adjusted	0.560 / 0.552	

*** significant at 1%, ** significant at 5%, * significant at 10% (weak significance)

Source: Author's analysis of CSO data (LCMS, 2015).

In the same way, distances to transport facilities and farm input markets did not significantly affect calories per capita from crop production since the stepwise regression excluded them for lacking a stronger relationship with calories per capita from crop production. Therefore, the last mile households produced as much quantity of crop as non-last mile households.

Expenditure on non-staple foods was significantly related to the proximity of a household to a farm input market. A kilometre closer to a farm input market increased expenditure on non-staple foods by US$ 0.05, as shown in Table 5.9. This negative relationship suggested that households closer to markets had easier access to a diversity of nutritious food as markets were far away. However, the coefficient was not significant in real terms since it was small, implying distance to a farm input market did not influence consumption spending on non-staple foods.

Table 5.9: Regression results for expenditure on non-staple foods

Predictors	**Estimates**	**p**
(Intercept)	14.2334***	<0.001
Kilometres to a farm input market	-0.0448*	0.085
Kilometres to a transport facility	0.1458	0.115
Poverty status (1=poor)	-4.8009**	0.014
Household head employed in agric. sector (1=yes)	-3.4149	0.083
Household size	-0.6609	0.059
Total monthly (US$)	0.3840***	<0.001
Asset value (US$)	-0.0027*	0.054
Dependency ratio	4.8606	0.133
Observations	763	
R^2 / R^2 adjusted	0.775 / 0.773	

*** significant at 1%, ** significant at 5%, * significant at 10% (weak significance)

Source: Author's analysis of CSO data (LCMS, 2015).

Similarly, the proximity to the nearest transport facility had no significant influence over the budget spent on non-staple foods. The poor state of transport facilities such as roads in rural areas could explain the lack of a considerable influence over expenditure on non-staple foods (Fungo *et al.*, 2017). The feeder roads surrounding households may have been impassable during certain seasons, leading to a reduced movement of non-staple foods to and from the last mile communities. Furthermore, the stepwise regression excluded the distance to a health centre as it did not strongly influence the household's expenditure on non-staple foods. These results suggested that last mile households spent as much on non-staple foods as the households which were not in the last mile areas.

In the same way, crop diversity did not depend on the last mile. The distance between a household and a farm input market had a statistically weak influence over the Crop Diversity Index (CDI). Nonetheless, Table 5.10 showed that a kilometre closer to a farm input market only increased CDI by 0.04 percent, suggesting no practical significance of the relationship. Local farm input markets may have failed to satisfy the farm input needs of the surrounding households coercing some of the farmers to seek distant markets (Fungo *et al.*, 2017).

Table 5.10: Tobit regression for crop diversity (CDI)

Predictors	Partial effects	p
(Intercept)	0.0146	0.6860
Household head age	0.0001**	0.0201
Household head sex (1=male)	0.0287*	0.0904
Household head self employed (1=yes)	0.1056***	0.0000
Household size	0.0052*	0.0540
Kilometres to a farm input market	0.0004*	0.0943
Asset value	0.00002*	0.0666
Expenditure on non-staple foods	0.0005*	0.0191
Central (1=yes)	0.1384***	0.0000
Copperbelt (1=yes)	0.1241***	0.0000
Lusaka (1=yes)	0.2991***	0.0000
Muchinga (1=yes)	0.0316	0.1451
Northern (1=yes)	0.0412	0.1432
Southern (1=yes)	0.0983***	0.0000
LL		

*** significant at 1%, ** significant at 5%, * significant at 10% (weak significance)

Source: Author's analysis of CSO data (LCMS, 2015).

Furthermore, after harvest, local markets may not have provided markets for certain crops produced by farming households. In this way, local markets did not stimulate crop diversity. Distances to transport facilities, food markets and health centres did not significantly predict crop diversity as the stepwise regression excluded them. Therefore, the last mile did not significantly determine the level of crop diversity among households in Zambia.

Other than the last mile, the study investigated the effect of demographic and socioeconomic variables on household food security. Households headed by self-employed household heads experienced a 15.4 percent higher crop diversity than households led by households heads who were not self-employed. This could be due to the increased income among self-employed household heads that enabled them to afford farm inputs for different crops (Goetz *et al.*, 2012; Kissoly *et al.*, 2018; Narain and Jeffers, 2020). The sex of the household head weakly influenced crop diversity. Table 5.10 showed that female-headed households had a higher crop diversity compared to male-headed households. However, the relationship was weak as it was significant at ten percent. The lack of a strong influence of gender on crop diversity could be due to the role played by extension services that could have reached out to both male and female-headed households (Ibrahim *et al.*, 2009). Nevertheless, some studies argued that female household heads increase crop diversity for income generation and nutrition purposes (Rehima and Dawit, 2012; Rehima *et al.*, 2013).

Equally, the age of the household head had a statistically significant effect on crop diversity. Households led by older household heads had higher crop diversity than households with younger household heads, suggesting that older farmers had farming experience, which enabled them to try new crops. Nonetheless, the coefficient was small, implying that the age of the household head did not have a significant practical influence on household crop diversity. The lack of strong effect of age of the household head could be due to the increased access to extension services which has been known to be a significant factor for crop diversity (Ibrahim *et al.,* 2009). Extension services were accessed by all household heads, which resulted in increased knowledge of the importance of crop diversity regardless of the age of the household head. Similarly, expenditure on non-staple foods, household size and assets' value had small coefficients implying that they did not affect crop diversity in real terms. This could be explained by the low crop diversity observed for most households in the sample.

The study found that households sampled from the Central, Copperbelt, Lusaka and Southern provinces had lower crop diversity compared to other provinces. The dominance of maize production in these provinces could be responsible for the reduced crop diversity (Chapoto *et al.,* 2016).

The number of hectares cultivated by a household increased calories per capita from crop production, as shown in Table 5.8. Expanding the field cultivated by one hectare resulted in a 16.6 percent increase in dietary energy produced by a household. By expanding the area cultivated, the household increased the quantities of farm inputs such as seeds, fertiliser and other farm inputs. Meanwhile, households that sold part of their crop had higher calories per capita from crop productions than households that did not sell any quantity of their crops. The positive influence of crop sales on calories per capita from crop production could be because commercialisation stimulated crop yield as households grew for consumption and sales (Ochieng *et al.,* 2016). The influence of commercialisation on calories per capita from crop production is an important result for Zambia's agricultural sector in graduating smallholder farmers into medium-scale or commercial farmers.

The adult labour ratio, defined as the number of household members older than 15 years but not exceeding 65 years divided by total household size, significantly affected calories per capita from crop production. Increasing the household labour ratio by one percent increased calories per capita from crop production by 26.9 percent. The higher adult labour ratio implied the availability of labour in the household that could be used for crop production activities (Ngongi and Urassa, 2014). However, the negative effect observed for household size suggested that most households had a significant number of members who were outside the active labour force. Additionally, larger households had low expenditure on farm inputs because they had greater financial responsibilities than smaller households (Ngongi and Urassa, 2014). This was consistent with the positive effect observed for expenditure on farm inputs, as presented in Table 5.8. The subsidised farm input distributed by the Ministry of Agriculture (MoA) could explain the small coefficient observed for farm input expenditure.

Sampled households from the Central, Lusaka, Muchinga and North-western provinces produced more calories per capita from crop production than sampled households from other provinces. This could be explained by the increased availability of crop markets and rainfall in these provinces compared to other provinces.

On the contrary, expenditure on non-staple foods did not depend on the provincial dummies suggesting that households spent the same when compared by province. However, households spent a larger budget on non-staple foods when monthly income increased. Similarly, non-poor households spent a larger non-staple food budget compared to poor households. These findings were consistent with Bennets' law which stipulated that increased income resulted in households substituting staple foods for non-staple foods (Godfray, 2011). The study also observed that larger households spent less on non-staple foods compared to smaller households. This could be because of the economic challenges and struggles of poverty associated with larger households, leading to reduced spending on non-staple foods (Godfray, 2011; Meyer and Nishimwe-Niyimbanira, 2016).

A household led by a household head employed in the agricultural sector spent a lesser budget on non-staple foods compared to a household whose household head worked in another sector. The findings suggested that households led by household heads employed in the agricultural sector reduced expenditure on non-staple foods because they grew diverse foods for home consumption (Dube, 2016). However, the coefficient was weak as it was significant only at the ten percent level.

5.4 Chapter summary

This chapter presented results of the analysis that related household food security to the last mile factors, namely distances to public facilities such as markets, transport facilities and health centres. The study observed some statistically significant relationships between the last mile and food security indicators. However, these relationships were either weak or not practically significant as they were significant at ten percent. The study concluded that there was no significant difference in food security between the last mile households and non-last mile households in Zambia. Therefore, the hypothesis stating that the last mile affected household foods security was rejected. Table 5.11 below summarises the sub-hypotheses and states whether they were accepted or rejected.

Table 5.11: Summary of effects of the last mile variables on food security indicators

The last mile indicator	Calories per capita from crop production	Expenditure on non-staple foods	Crop diversity
Proximity to the food market	(-) but small coefficient	0	0
Proximity to transport facility	0	0	0
Proximity to the health centre	0	0	0
Proximity to the farm input market	0	(-) but weak relationship	(-) but weak relationship

Note: (-): Negative effect, 0: no significant effect

CHAPTER 6: THE EFFECT OF THE LAST MILE ON CHILD NUTRITION

This chapter presents the results answering the study's second objective that sought to determine the effect of the last mile on child nutrition outcomes. Section one discusses the goodness of fit as well as the results regarding the diagnostic tests of the models used. The second section presents the descriptive statistic results for child nutrition outcome indicators. Additionally, section two presents the outputs of the models regressing the last mile, socioeconomic and demographic variables on child nutrition indicators. The chapter ends by summarising the findings and stating the rejection or the acceptance of the hypothesis claiming that the last mile affected child nutrition outcomes.

6.1 Model fit and results for diagnostic tests for regressions assumptions

The study ran four multilevel models to analyse the last mile's effect on child nutrition outcomes. These models included Height-for-Age Z-scores (HAZ), Weight-for-Age Z-scores (WAZ), BMI-for-Age Z-scores (BAZ) and Weight-for-Height Z-scores (WHZ). In ensuring that the model results were reliable, the study ran diagnostic tests to determine whether the assumptions were valid. The regression outputs showed that the models gained a better fit with the addition of predictors. Table 6.1 below shows that the absolute values of the AIC and log-likelihood were smaller in full models compared to the null models. The Chi-square tests generated significant p-values confirming that full models had a significantly better fit than null models.

Table 6.1: Comparison of the fit of the null and full models

	HAZ		**WAZ**		**BAZ**		**WHZ**	
	Null	Full	Null	Full	Null	Full	Null	Full
AIC	3354.1	3316.4	2477.5	2421.1	3399.2	3370.7	3168.9	3145.1
BIC	3367.9	3381.0	2491.3	2494.9	3413.1	3426.1	3182.7	3200.3
LL	-1674	-1644.2	-1235.8	-1194.6	-1696.6	-1673.4	-1581.5	-1560.5
P-val	0.000***		0.000***		0.000***		0.000***	

*** significant at 1%, ** significant at 5%, * significant at 10% (weak significance)

Source: Author's analysis of CSO data (LCMS, 2015).

Levene's test found that the multilevel models, BAZ, HAZ, WAZ and WHZ models, did not violate homoskedasticity. This meant that the variance of the error term was constant across the observations in the sample. Equally, the assumption of the normal distribution of the model residuals was not violated. The overall line plotted in Q-Q plots generated did not significantly deviate from the straight lines dotted in the graphs below.

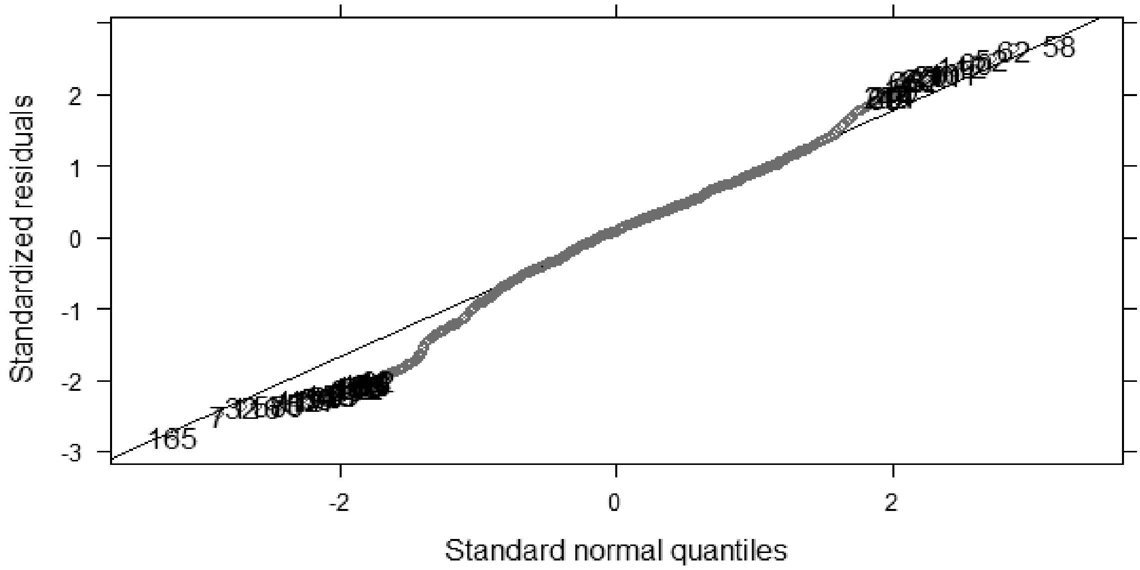

Figure 6.1: Q-Q plot for the HAZ model

Source: Author’s analysis of CSO data (LCMS, 2015).

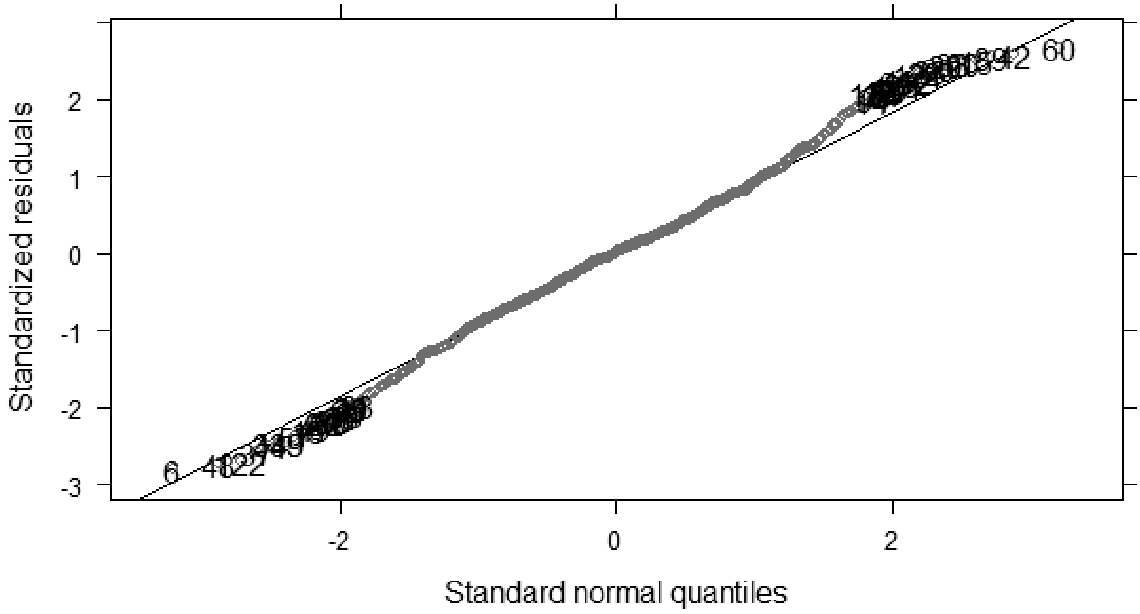

Figure 6.2: Q-Q plot for the WAZ model

Source: Author’s analysis of CSO data (LCMS, 2015).

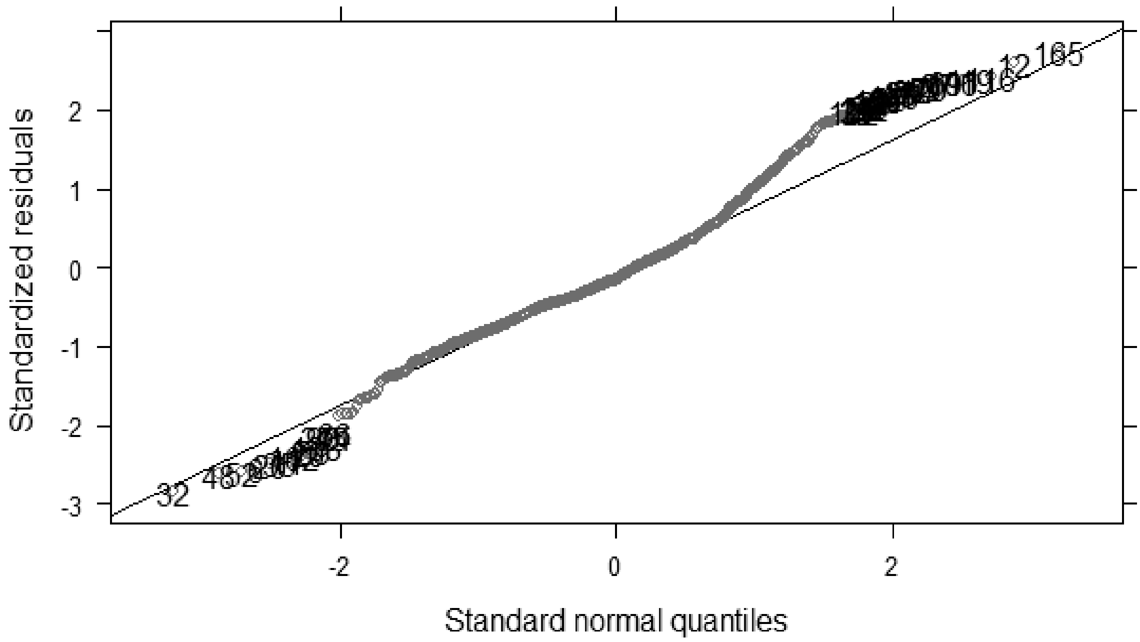

Figure 6.3: Q-Q plot for the BAZ model

Source: Author's analysis of CSO data (LCMS, 2015).

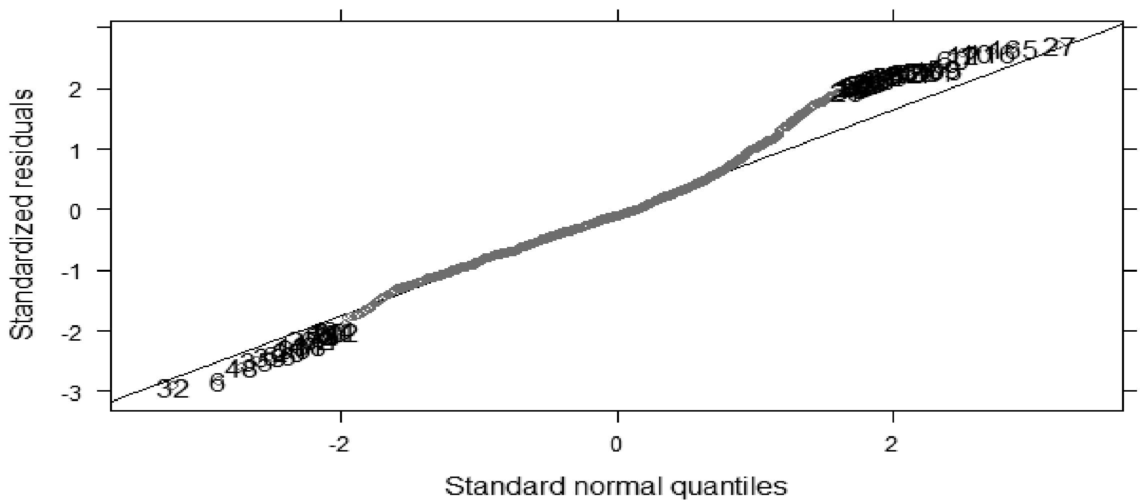

Figure 6.4: Q-Q plot for the WHZ model

Source: Author's analysis of CSO data (LCMS, 2015).

Meanwhile, the test for multicollinearity showed that all the variables in the respective models were not linearly related. The VIF values given in Table 6.2 below were all less than five, implying no linear relationship among independent variables in the models.

Table 6.2: Results for the test for multicollinearity - Variance Inflation Factors (VIFs)

Predictor	HAZ	WAZ	BAZ	WHZ
CDI		1.10		
Child age in months months	1.04	1.02		
Child lives with mum (1=yes)			1.01	1.01
Child sex (1=male)		1.02		1.01
Hectares cultivated cultivated		1.81		1.55
Household head age		1.53		
Household head education level	1.28			1.13
Household head formally employed (1=yes)		1.03		
Household head married (1=yes)			1.04	
Household size	1.49			
Kilometres to a food market	1.08	1.12		
Maternal age	1.2			1.03
Maternal education	1.38		1.10	
Non-staple expenditure			1.08	
Per capita expenditure				1.28
Calories per capita from crop production		1.68		1.69
Biological child to the household head (1=yes)		1.44		
Total monthly income	1.42			
Central (yes=1)	1.23	1.12	1.12	1.05
Copperbelt (yes=1)	1.18		1.09	
Lusaka (yes=1)	1.08		1.05	1.03
Northern (yes=1)		1.05	1.05	
Southern (yes=1)	1.19	1.15		
Western (yes=1)		1.16	1.06	

Source: Author's analysis of CSO data (LCMS, 2015).

6.2 Discussion of the results of the descriptive statistics and regression outputs

There were 745 children under the age of five years considered for the analysis of the last mile's effect on child nutrition. These were the children who had complete data on the variables of interest in the analysis. The analysis found that undernourishment was a problem among the children from the sampled households. The prevalence of child stunting stood at 55.30 percent, while the rate of underweight and wasting stood at 13.15 percent and six percent. The comparison with the 2014 Zambia Demographic Health Survey (ZDHS) report showed that the prevalences of underweight (15 percent) and wasting (six percent) remained relatively the same (CSO, 2015). Despite the difference between the prevalence of stunting (55.30 percent) reported in this study and the 40 percent reported by the 2014 ZDHS, there is agreement that stunting is high in Zambia (CSO, 2015). The Central province recorded the highest rate of child stunting, while the Lusaka province recorded the lowest rate, as presented in Table 6.3.

Table 6.3: Prevalence of undernourishment among children under five years of age

Province	Stunted (%)	Underweight (%)	Wasting (%)	BAZ<-2SD (%)
Central	63.81	9.52	4.90	4.76
Copperbelt	59.05	17.14	6.93	4.76
Eastern	57.14	17.29	3.79	4.51
Luapula	57.89	14.47	3.95	3.95
Lusaka	41.18	17.65	17.65	11.76
Muchinga	58.18	9.09	10.91	10.91
N. Western	51.52	6.06	3.33	9.09
Northern	51.52	15.15	6.25	3.03
Southern	43.09	10.57	4.88	4.88
Western	62.50	10.42	6.25	6.25
Nationwide	55.30	13.15	6.00	5.64

Source: Author's analysis of CSO data (LCMS, 2015).

The high rate of stunting among the sampled children in the Central province (63.81 percent) could partly result from low crop diversity (see Table 5.6) in the province that limited dietary diversity at the household level. However, the low rate of stunting observed for the Lusaka province (41.18 percent) could be due to the lower poverty levels and high economic activity in the province compared to other provinces. Surprisingly, the Lusaka province recorded the highest prevalence of wasting. This could be due to the higher cases of diarrhoeal diseases that Lusaka province faces compared to other provinces (Mwaba *et al.,* 2020). Between 2008 and 2017, Lusaka province recorded 83.2 percent of Zambia's cholera cases (Mwaba *et al.,* 2020).

Children living in households closer to food markets had higher WAZ scores than their counterparts in households far away from food markets. WAZ increased by 0.01 scores for every kilometre reduction in the distance from a food market, as shown in Table 6.4. The better nourishment observed for children living closer to food markets could be because they had increased access to diverse foods compared to their counterparts further away (Abay and Jensen, 2020). However, the fact that the data was collected in May 2015, a month of transitioning from lean season to a post-harvest season, suggested that the effect of proximity to markets could have been greater. This is because markets get stocked with diverse foods after harvest. Meanwhile, distances to health centres, transport facilities and farm input markets did not strongly affect WAZ scores and were excluded from the analysis by the stepwise regression.

Table 6.4: Multilevel regression results for the WAZ model

Predictors	Estimates	p
(Intercept)	-1.2850***	<0.001
Child age in months	-0.0153***	<0.001
Calories per capita from crop production	0.0001***	<0.001
Kilometres to a food market	-0.0138***	<0.001
Own child to household head (1=yes)	0.5230***	0.001
Household head formally employed (1=yes)	0.2352*	0.074
Child gender (1=male)	-0.1778**	0.045
Hectares cultivated	-0.1382***	0.003
Household head age	0.0114**	0.032
CDI	0.4820**	0.037
Central (1=yes)	0.3840***	0.004
Western (1=yes)	0.5019**	0.010
Southern (1=yes)	0.3336***	0.009
Northern (1=yes)	0.3912*	0.076
Observations	745	
ICC	0.04	

*** significant at 1%, ** significant at 5%, * significant at 10% (weak significance)
Source: Author's analysis of CSO data (LCMS, 2015).

Linear growth of children under the age of five years did not depend on the proximity of a household to a food market. The lack of a significant effect of distance to a food market on HAZ suggested that there was no difference in linear growth between children living near and far away from a food market, as shown in Table 6.5

Table 6.5: Multilevel regression results for the HAZ model

Predictors	Estimates	p
(Intercept)	-2.0312***	<0.001
Kilometres to a food market	-0.0104	0.139
Child age in months	-0.0230***	<0.001
Maternal age	0.0423***	0.001
Maternal education level	-0.0536	0.186
Total monthly (US$)	0.0042***	<0.001
Household head age	-0.0459	0.152
Household size	-0.0967***	0.006
Central (1=yes)	-0.5914**	0.021
Copperbelt (1=yes)	-0.4280*	0.093
Lusaka (1=yes)	0.6109	0.133
Southern (1=yes)	0.4442*	0.062
ICC	0.04	
Observations	745	

*** significant at 1%, ** significant at 5%, * significant at 10% (weak significance)

Source: Author's analysis of CSO data (LCMS, 2015).

Proximity to a farm input market, health centre and transport facilities were excluded from the model by the stepwise regression due to weak relationships with the HAZ scores. Similarly, the last mile did not strongly influence BMI for age Z-scores and WHZ scores of children under five years or age. The stepwise regression eliminated the last mile variables for lacking a strong relationship with BAZ and WHZ scores, as shown in Table 6.6 and Table 6.7. The lack of a significant effect of the last mile variables on BAZ and WHZ scores implied that the prevalence of thinness (BAZ) and wasting (WHZ) for children under five years did not depend on whether a child lived in the last mile or non-last mile household.

Table 6.6: Multilevel regression results for the BAZ model

Predictors	Estimates	p
(Intercept)	-1.6173*	0.066
Non-staple food expenditure (US$)	-0.0060**	0.010
The child lives with the mother (1=yes)	1.9452**	0.011
Household head married (1=married)	0.4765	0.141
Maternal education	0.0727*	0.054
Central (1=yes)	1.1733***	<0.001
Lusaka (1=yes)	-0.8000*	0.055
Northern (1=yes)	0.8333**	0.047
Copperbelt (1=yes)	0.4459*	0.081
Western (1=yes)	0.6267*	0.074
ICC	0.06	
Observations	745	

*** significant at 1%, ** significant at 5%, * significant at 10% (weak significance)
Source: Author's analysis of CSO data (LCMS, 2015).

Table 6.7: Multilevel regression results for the WHZ model

Predictors	Estimates	p
(Intercept)	0.0943	0.906
Chid's sex (1=male)	-0.2060	0.172
Maternal age	-0.0251**	0.025
The child lives with the mother (1=yes)	1.5108**	0.028
Per capita expenditure (US$)	-0.0145**	0.032
Household head grade	0.0427	0.127
Hectares cultivated	-0.1618**	0.027
Calories per capita from crop production	0.0001*	0.059
Central (1=yes)	0.9686***	<0.001
Lusaka (1=yes)	-0.8254**	0.024
ICC	0.04	
Observations	733	

*** significant at 1%, ** significant at 5%, * significant at 10% (weak significance)
Source: Author's analysis of CSO data (LCMS, 2015).

Based on the regression outputs, the study found that proximity to health centres, transport facilities and farm input markets did not affect HAZ, WHZ and BAZ scores. The lack of a significant effect of proximity to health facilities on child nutrition could be due to the involvement of the nutrition community volunteers who reached both households far and near health centres (Juarez *et al.,* 2021; Muremyi, 2020; NFNC, 2011). Equally, transport facilities such as water and railway did not influence child nutrition because they were not popular means of transport among households (Toro, 2016). According to Fungo *et al.* (2017), local markets failed to significantly affect food security and nutrition if they did not meet the market needs of the households. For this reason, proximity to farm input markets did not significantly affect child nutrition as they did not provide an adequate supply of farm inputs for crop diversity, an important factor driving food security and nutrition.

The age of a child had a strong negative influence on HAZ and WAZ scores of the children under five years. An additional month in the age of the child reduced HAZ and WAZ by 0.02 scores each. These observations could be because of reduced child care as the children grew (Masiye *et al.,* 2010). Furthermore, poor nutrition in older children could have resulted from inadequate diets as they transitioned from complementary foods to normal family foods (Mokori *et al.,* 2017). Moreover, complementary foods may be contaminated in certain cases leading to increased diarrheal diseases, which are known risk factors of child malnutrition (Kosek *et al.,* 2013).

Children had higher WAZ, BAZ and WHZ scores if they lived with their biological mother and if the household head was the biological parent. The increased nutrition outcome scores could be due to increased child care offered by biological parents compared to other relatives (Masiye *et al.,* 2010). Meanwhile, higher WAZ scores were recorded for female children than their male counterparts. A female child had additional 0.18 WAZ scores than a male child. The differences in the WAZ scores based on the sex of a child could be due to certain behavioural practices employed by communities, such as favouritism for daughters. This favouritism could translate into differences in diets given to children of a given sex (Chirande *et al.,* 2015). Additionally, the biological differences between male and female children, such as increased morbidity in children, could explain the higher nutrition outcomes in females than male children (Elsmén *et al.,* 2004; Kilbride and Daily 1998; Masiye *et al.,* 2010).

Children with more educated mothers recorded higher BAZ scores. Although the relationship was weak, the result suggested that maternal education increased access to nutritional information, resulting in increased child nutrition (Nankinga *et al.,* 2019). Maternal age and household head's age positively influenced HAZ and WAZ scores, respectively. Older mothers and household heads gained experience and knowledge of child nutrition, resulting in increased nutrition outcomes (Nankinga *et al.,* 2019). Nevertheless, WHZ scores reduced with maternal age. As maternal age increased, birth order and the number of children under five years increased, leading to poor quality of nutritional care due to the increased number of children (Cruz *et al.*, 2017; Harding *et al.*, 2018).

The number of hectares cultivated positively affected the number of underweight and wasted children under five years. This is because cultivating an additional hectare of a field reduced WAZ by 0.14 scores and WHZ by 0.16 scores. The poor nutrition observed among households cultivating bigger fields could be due to the dependency on own-produced foods for consumption as opposed to engaging in food purchases (Matita *et al.,* 2021; O'Meara *et al.,* 2019). While children in households that engaged in food purchases had better access to diverse foods during all seasons, children from households that depended on their production had poor access to a diversity of foods when their stocks were depleted, particularly in leans seasons (Connors *et al.,* 2021; Matita *et al.,* 2021; O'Meara *et al.,* 2019). Moreover, the negative effect of hectares cultivated on child nutrition also suggested competition between expenditure on farm inputs and food. Households cultivating bigger fields could have reduced expenditure on nutritious foods to purchase farm inputs, thus compromising child nutrition.

Children belonging to larger households had lower HAZ scores compared to their counterparts in smaller households. Increasing the household size by one member reduced HAZ by 0.1 scores. The reduced nutrition with increased household size could be explained by the economic and food security struggles associated with larger households (Cleland *et al.,* 2006; Geberselassie *et al.,* 2018). The study also observed that total monthly income had a positive effect on children's linear growth. However, the coefficient was very small, implying that the effect of total monthly income was not significant in real terms. Total monthly income may have failed to significantly influence child nutrition because some of the nutritional requirements were met by own agricultural production.

Similarly, household expenditure on non-staple foods was not significantly related to BAZ scores because the coefficient was small. This could be explained by the strong effect of crop diversity on child nutrition observed in Table 6.6. A percentage increase in crop diversity resulted in a 0.48 WAZ scores increment among children under five. Children living in households with higher crop diversity were better nourished because they had access to various nutritious foods.

Children in the Lusaka province recorded lower BAZ and WHZ scores than their counterparts from other provinces. This could be explained by the higher diarrhoeal cases that Lusaka province experiences compared to other provinces (Mwaba *et al.*, 2020). On the other hand, higher scores for WAZ and HAZ were recorded for children living in households sampled from the Southern province. This could be because, among other factors, the Southern province accounts for the largest number of households involved in livestock raring (CSO, 2019). Similarly, children sampled from the Central province, another region with a considerable proportion of households raring livestock, recorded higher WAZ, BAZ and WHZ scores, although lower HAZ scores (CSO, 2019). The increased nutrition among children living in households raring livestock could be because they had better access to animal source foods such as milk and meat (Hetherington *et al.*, 2017).

6.3 Chapter summary

This chapter discussed the results of the analysis of the last mile's effect on child nutrition to answer the second objective. The study found that distance to a food market was important in explaining WAZ scores. However, the rest of the last mile variables did not affect all the child nutrition indicators. Therefore, the study partially accepted the hypothesis that the last mile affected child nutrition outcomes.

Table 6.8 below summarises the findings of the study presented in this chapter.

Table 6.8: Summary of study hypotheses

The last mile indicator	HAZ	WAZ	BAZ	WHZ
Kilometre to the food market	0	(-)	0	0
Kilometre to transport facility	0	0	0	0
Kilometre to the health centre	0	0	0	0

Note: (-): Negative effect, 0: no significant effect

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

The last mile is a threat to socioeconomic development and food security. It is generally understood that last-mile households may be trapped in food insecurity because they have poor access to markets to purchase food or sell their agricultural products to generate income. It is equally challenging for outsiders to offer food assistance due to the high logistical costs resulting from poor road conditions and connectivity, among other factors. Poor road network (such as limited access to all-season roads) leads to poor access to health centres and transport facilities. In SDG nine, the United Nations seeks to increase the proportion of the rural population living within two kilometres of an all-season road. Research investigating the effect of the last mile on food security is crucial for developing policies to achieve the targets for SDGs two and nine in particular.

This study sought to investigate the last mile effect on food security in 69 selected districts of Zambia. The first specific objective was to establish how the proximity of a household to public facilities affected calories per capita from crop production, crop diversity and household expenditure on non-staple foods. In the second specific objective, the study sought to determine the effect of the proximity of a household to public facilities on child nutrition outcomes. Two hypotheses were stated in the affirmative, claiming that the proximity of a household to public facilities affected both household food security and child nutrition outcomes.

The study found that the proximity of a household to a market statistically increased calories per capita from crop production, crop diversity and expenditure on non-staple foods. However, the coefficients were small, implying that the proximity of a household to a market did not affect food security in real terms. The lack of significant influence of proximity to market on household food security could be because local markets did not meet the market needs of farming households, such as adequate farm input supply. Similarly, the proximity of a household to a health centre and transport facility did not significantly affect household food security. Transport facilities such as feeder roads may become impassable during certain seasons, thus limiting the flow of food products in and out of the community. Moreover, while health facilities were accessible to these communities, no information was available about the quality of services, especially child nutrition and dietary advice. Health centres may have concentrated on their primary roles, such as disease treatment and prevention. Therefore, the hypothesis that the last mile affected household food security was rejected for this sample.

The likelihood of a young child being underweight (as indicated by the WAZ score) increased among households further away from a food market. Beng one kilometre closer to a food market significantly increased a child's WAZ score by 0.01. Children who were closer to food markets may have been better nourished because they had access to a greater diversity of nutritious foods from the food markets. Nonetheless, the proximity of a household to a health centre and transport facility did not influence child nutrition outcomes. Therefore, the hypothesis that claimed that the last mile affected child nutrition was partially accepted.

7.1 Conclusions

The study arrived at four conclusions. First, the last mile did not affect household food security in terms of the variables included in the study. Calories per capita from crop production, crop diversity and expenditure on non-staple foods did not depend on the distance from a market, health centre or transport facility. Local markets did not influence household food security, perhaps because they did not provide adequate farm inputs or a market for selling crops. Furthermore, transport facilities such as feeder roads did not significantly influence household food security because they were impassable in certain seasons.

Second, children living in last-mile households were more likely to be underweight. Households located nearer to a food market may have been able to access a variety of nutritious foods and economic opportunities such as wage employment that are important to food security. However, linear growth (stunting) and weight-for-height z-scores (wasting) were not affected by a household's distance from a food market. Furthermore, the proximity of a household to a health centre and transport facilities did not affect child nutrition. Children living near transport facilities such as feeder roads were not better nourished than their counterparts living further away because the feeder roads were impassable in certain seasons.

Third, socioeconomic and demographic factors strongly determined food security and children's nutrition status. For example, household food security improved with the availability of active family labour, income and crop commercialisation, while food insecurity deteriorated with increased household size. Therefore, efforts to address food insecurity should encourage, among others, crop commercialisation and smaller families. On the other hand, children were better-nourished if they lived with their mothers or if the household head was a biological parent. Furthermore, child nourishment was better among female children as well as with the increased age of the household head, the hectarage cultivated and crop diversity grown. Therefore, NFNSP, SUN 1st 1000 MCDP and other child nutrition policies should consider crop diversity, family planning and cultural factors responsible for the differences in nutrition between male and female children.

Finally, the significant influence of dummies representing the provinces suggested that unique characteristics affected food security. For example, households sampled from the Central and Lusaka provinces produced higher crop quantities but had low crop diversity. This could be because calories per capita from crop production among rural households in these provinces was dominated by maize production. Maize is a staple food in these provinces and for this reason, households allocated more resources to maize production, leading to lower crop diversity. Furthermore, mining activities in the Copperbelt province could be the reason for the low crop diversity as household heads may have been engaged in off-farm employment at the mines. Therefore, interventions addressing household food security should consider the individual differences of provinces. For example, extension services targeting households from Central, Lusaka and Southern provinces where maize dominates calories per capita from crop production should emphasise crop diversification as an essential component of food security.

7.2 Recommendations

The study recommends support for the establishment of food markets to enhance efforts to address undernourishment. More food markets should be built in the last mile communities to reduce the distances household members would have to travel to purchase food or sell their agricultural surplus. Additionally, transport facilities such as feeder roads should be kept in good condition to facilitate the transportation of food and agricultural products between the last mile households and markets across all seasons. This would enhance food security because households could have increased access to a diversity of nutritious foods not produced in their communities. All-season roads will also improve the local supply of various farm inputs which are critical for crop production and diversity.

The study also recommends that more households should be encouraged to grow other crops such as groundnuts, soybeans, sweet potatoes and vegetables. Incentives such as the inclusion of farm inputs for other crops in the FISP package, preferential purchasing agreements and establishing food processing facilities in these communities could act as a pull factor for increasing the production of a more diversified range of crops. As a result of crop diversity, household food security and child nutrition will improve.

The Ministry of Agriculture (MoA) should enhance its efforts to promote crop commercialisation among farming households to increase calories per capita from crop production. By promoting crop commercialisation the MoA could increase calories per capita from crop production but also accelerate the progress of graduating smallholder farmers into intermediate scale farmers. Furthermore, crop commercialisation will increase household income which would be an important step towards Zambia becoming a middle-income country by 2030, as stated in the Vision 2030.

Finally, policies should encourage households to have smaller families to enhance household food security and nutrition. For this reason, nutrition messages should incorporate family planning messages to target women of childbearing age. This is because child nutrition deteriorates with an increased number of children under five years, particularly as mothers get older.

7.3 Contribution to knowledge

Very few studies related the last mile to food security and nutrition, particularly in the Zambian context. The findings of this study contributed to the understanding of how the last mile affected food security and nutrition. The proximity of a household to the nearest food market played an important role in reducing underweight in children under five years.

The study also contributes to the debate on whether Zambia should extend its road network. It is viewed that expanding the road network could improve access to markets, increase social inclusion, increase agricultural investment and reduce transport costs in last-mile communities. However, it could also be contended that building new high standard roads would be uneconomical for Zambia because most of its areas are remote and low densely populated. This study's findings favour the argument of maintaining the road network as opposed to extending it.

7.4 Recommendations for the improvement of the study

This study could have been improved in several ways. Firstly, district road density could have been included to account for the effect of the road network on food security and nutrition. District road density has been found to have a significant effect on food security and nutrition. However, these data were not available for all the districts investigated. The second way in which this study could have been improved would have been by disaggregating transport facilities into roads, water and rail transport. However, disaggregated data was not available because it was not collected in the survey. Dissagregagted data would allow for deeper analysis of the effect of the proximity to a road as roads are the most common transport facility used by households compared to rail and water transport. Moreover, the proximity of a household to public facilities should include the time taken to reach a given facility as an alternative to the distance in kilometres**.**

7.5 Recommendations for further research

Future studies should include district road density in similar analyses. The data on household access to public facilities could be more accurate by using digital devices such as google map and GPS to capture the distances. In addition, future surveys should capture the exact time in minutes or hours taken to access a given public facility. The study also recommends using Multiple Imputation (MI) and Full Maximum Likelihood Estimation (FIML) to handle the missing data in the dataset.

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ANNEX A: LIST OF THE DISTRICTS IN THE STUDY

1. Chadiza	21. Kalulushi	41. Mbala	61. Samfya
2. Chama	22. Kaoma	42. Milenge	62. Senanga
3. Chavuma	23. Kapiri Mposhi	43. Mkushi	63. Serenje
4. Chibombo	24. Kaputa	44. Mongu	64. Sesheke
5. Chienge	25. Kasama	45. Monze	65. Shang'ombo
6. Chililabombwe	26. Kasempa	46. Mpika	66. Siavonga
7. Chilubi	27. Katete	47. Mpongwe	67. Sinazongwe
8. Chingola	28. Kawambwa	48. Mporokoso	68. Solwezi
9. Chinsali	29. Kazungula	49. Mpulungu	69. Zambezi
10. Chipata	30. Kitwe	50. Mufulira	
11. Choma	31. Luangwa	51. Mufumbwe	
12. Chongwe	32. Luanshya	52. Mumbwa	
13. Gwembe	33. Lufwanyama	53. Mungwi	
14. Ikelenge	34. Lundazi	54. Mwense	
15. Isoka	35. Luwingu	55. Mwinilunga	
16. Itezhi Tezhi	36. Mafinga	56. Nakonde	
17. Kabompo	37. Mambwe	57. Namwala	
18. Kafue	38. Mansa	58. Nchelenge	
19. Kalabo	39. Masaiti	59. Nyimba	
20. Kalomo	40. Mazabuka	60. Petauke	

ANNEX B: VARIABLES AND THEIR DEFINITIONS

Variable	**Definition**
Asset value	The monetary value of assets in kwacha (US$)
Child age in months	Age of child in months
Expenditure on non-staple food	The amount spent on non-staple foods (US$)
Hectares cultivated	The total area cultivated (hectares)
Household adult labour ratio	The ratio of household members aged 15 years<x≤65 years to total household size
Farm input expenditure	The total expenditure on crop inputs
Household crop sales (yes=1)	Dummy: 1 if household sold some of the crop produced, 0 otherwise
Household dependency ratio	The ratio of household members <15 and 65< years to total household size
Household food production	The quantity of food produced
Household head age	Age in years of the household head
Household head gender	Sex of household head (male=1)
Household head highest grade	The highest grade attained by the household head
Household head married	Dummy: 1 if the household head was married, 0 otherwise
Household head self-employed	Dummy: 1 if the household head was self-employed, 0 otherwise
Household poverty status (yes=1)	Dummy: 1 if the household was poor, 0 otherwise
Household size	Number people in the household
Maternal age	Age in years of mother
Maternal education level	The highest grade attained by mother
Per capita expenditure	Monetary expenditure per person in a household

Variable	Definition
The child lives with the biological mother	Dummy: 1 if the child lives with the mother, 0 otherwise
The household head was in the formal employment	Dummy: 1 if the household head was in formal employment, 0 otherwise
The household head was in the agriculture sector	Dummy: 1 if the household head was employed in the agricultural sector, 0 otherwise
The household head was the child's biological parent	Dummy: 1 if the household head was the biological parent, 0 otherwise
Total monthly income	The total amount of money earned by household members (K)
Kilometres to the nearest food market	Distance between a household and food market
Kilometres to the nearest health centre	Distance between a household and health centre
Kilometres to nearest farm input market	Distance between a household and farm input market
Kilometres to nearest transport facility	Distance between a household and transport facility
Central province (yes=1)	Dummy: 1 household belonged to the Central province, 0 otherwise
Copperbelt province (yes=1)	Dummy: 1 household belonged to the Copperbelt province, 0 otherwise
Eastern province (yes=1)	Dummy: 1 household belonged to the Eastern province, 0 otherwise
Luapula province (yes=1)	Dummy: 1 household belonged to the Luapula province, 0 otherwise
Lusaka province (yes=1)	Dummy: 1 household belonged to the Lusaka province, 0 otherwise
Muchinga province (yes=1)	Dummy: 1 household belonged to the Muchinga province, 0 otherwise
Northern province (yes=1)	Dummy: 1 household belonged to the Northern province, 0 otherwise
North western province (yes=1)	Dummy: 1 household belonged to the North-Western province, 0 otherwise
Southern province (yes=1)	Dummy: 1 household belonged to the Southern province, 0 otherwise
Western province (yes=1)	Dummy: 1 household belonged to the Western province, 0 otherwise