IMPACT OF LARGE-SCALE AGRICULTURAL INVESTMENT SUPPORT ON SMALLHOLDER AGRICULTURAL COMMERCIALISATION: A CASE OF AMATHEON AGRI ZAMBIA

By

Eurelia Mutinta Kazekula

Department of Agricultural Economics and Extension Studies

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UNIVERSITY OF ZAMBIA

LUSAKA

DECLARATION

I, **Eurelia Mutinta Kazekula** declare that this thesis:

a) Represents my own work;
b) Has not previously been submitted for a degree at this or any other University, and
c) The work enshrined in the thesis is the product of my own work except where duly acknowledged.

Signed: .....

Date: .....

CERTIFICATE OF APPROVAL

This dissertation by Eurelia Mutinta Kazekula is approved as fulfilling the requirements for the award of Master of Science in Agricultural Economics degree by the University of Zambia.

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Examiner 2	Signature	Date
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Examiner 3	Signature	Date
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Supervisor	Signature	Date
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Co-Supervisor	Signature	Date

ABSTRACT

Smallholder farmers in Africa are perpetually constrained by a number of factors such as limited market access, poor infrastructure, and low production and productivity which in turn affects their levels of commercialisation. One strategy that has been touted as the panacea to the low levels of smallholder agricultural commercialisation is the corporate social responsibility (CSR) initiative by foreign-owned large-scale agricultural investments (LSAIs) aimed at transforming traditional subsistence farming into commercially viable enterprises. Using the case study of Amatheon Agri Zambia limited (AAZ), a German-owned company with approximately 40,000 hectares of land in Central Zambia, the overarching objective of this study was to investigate the impact of AAZ's nucleus out grower scheme programme on smallholder agricultural commercialisation in Mumbwa and Chibombo districts. The study used secondary longitudinal data from 590 households collected in 2018 and 2021 to address three specific objectives: (i) to examine the level of agricultural commercialisation between participants and non-participants of the AAZ out grower scheme; (ii) to determine the key drivers of agricultural commercialisation among smallholder farmers, and; (iii) to estimate the impact of the AAZ out grower scheme interventions on smallholder agricultural commercialisation. Summary statistics were computed to compare the levels of commercialisation between participants and non-participants using three household commercialisation indices generated for maize, soya beans and an aggregate crop index. The three household commercialisation indices were also used as outcome variables for the fractional regression approach to explore the key determinants of smallholder agricultural commercialisation in the context of nucleus out grower schemes. To estimate the impacts of AAZ support on agricultural commercialisation, propensity score matching techniques were used prior to the computation of average treatment effects. Factors such as age of the household head, ownership of agricultural assets, household wealth, maize yield, average maize price per unit, farm size, and distance to Lusaka influenced maize commercialisation. Soya bean commercialisation was influenced by ownership of agricultural assets, yield, and farm-gate prices. Crop commercialisation was influenced by household size, education level, grain sales to AAZ, loan access, agricultural assets, and total land cultivated, with household head age negatively affecting commercialisation. Results further show a general significant increase in commercialisation between the treatment and control groups at both study rounds with soya beans being farmed for commercial purposes. Maize farmers in the AAZ scheme are medium commercialised and overall crops are highly commercialised. There was a decline of soya beans at the end line particularly due to AAZ's strategic shift to high-value crops and restructuring of its out grower scheme. In the treated group, 61.08% of individuals are engaged in maize commercialisation, compared to 49.45% in the control group. The Average Treatment effect on the Treated (ATT) indicates a significant difference in maize commercialisation between the groups, suggesting that AAZ's support enhances smallholder farmers' maize commercialisation by 61.08% relative to those without AAZ support. However, the average treatment effect for soya bean commercialisation is minimal, with T-statistics showing no significant difference, implying that AAZ's impact on soya bean commercialisation is similar for both treated and control groups. Consequently, 83.0% of households that received AAZ support commercialised soya beans, mirroring the effect on non-participating households. Additionally, the AAZ support does not differ in its impact on overall crop commercialisation between the treated and control groups, indicating that participants and non-participants experience the same level of intervention effect by 74.6% on the marketing of cowpeas, sunflower, groundnuts, and vegetables. In conclusion, this research underscores the positive influence of LSAIs, particularly AAZ, on smallholder agricultural commercialisation in Zambia. Policy recommendations include targeted support to enhance education, promote asset ownership, and improve market access. Additionally, diversifying crops and building resilience

against natural shocks are vital. These findings provide valuable insights for policymakers and stakeholders, guiding strategies for sustainable agricultural development in SSA.

Key Terms: *Large-Scale Agricultural Investments (LSAIs), Smallholder Farmers, Agricultural Commercialisation*

DEDICATION

My mother Christine Kazani Kazekula, whose love is too deep to quantify, has my undying devotion. She has always been my biggest inspiration to work harder and overcome life's obstacles head-on and has served as my cheerleader. Your encouraging comments stick with me, and I am constantly reminded of how much you believe in me when I am about to give up. I will light the lantern and keep it burning bright. I love you baama.

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To my mother and siblings, thank you for your unwavering support throughout my life. Your inspiration has been invaluable, and I appreciate your understanding of my busy schedule.

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LIST OF ABBREVIATIONS

AAZ	Amatheon Agri Zambia Limited
ATT	Average Treatment on the Treated
ATU	Average Treatment on the Untreated
CA	Conservation Agriculture
CAPI	Computer Assisted Personal Interviews
CFU	Conservation Farming Unit
DIE	Deutsche Instit0ut für Entwicklungspolitik
FAO	Food Agriculture Organisation
FC	Farmer Coordinator
FCGs	Farmer Controlled Groups
FGDs	Focus Group Discussions
GDI	German Development Institute
HCI	Household Commercialisation Index
HH	Household
KII	Key Informant Interviews
KMO	Kaiser-Meyer Olkin Test
LSAIs	Large-Scale Agricultural Investments
MS	Microsft
PBR	Per Cent Bias Reduction
PCA	Principal Component Analysis
PSM	Propensity Score Matching
QGIS	Quantum Geographic Information System
SSA	sub-Sahara Africa
UNZA	University of Zambia
US$	United States Dollar
USAID	United States Agency for International Development
WB	World Bank
ZMW	Zambian Kwacha

CHAPTER ONE- INTRODUCTION

1.1. Background

After the crisis that disrupted the global food supply in 2007/8, there was an upsurge in Large-Scale Agricultural Investments (LSAIs) by foreign-owned companies that purchased land in developing nations, including those in sub-Saharan Africa (SSA) (Cotula and Vermeulen, 2009; Deininger, 2011; Baumgartner *et al.*, 2015; Speller *et al.*, 2017). According to the Land Matrix (2020), land deals of over 13 million hectares were concluded in SSA in 2020. One of the countries where foreign commercial investments were made in agriculture is Zambia. This was possible, in part, due to the government's policy of attracting investments by encouraging farmland acquisitions. The farm block programme, which aimed to target one million hectares across all ten provinces of Zambia, was a notable initiative (Matenga and Hichaambwa, 2017). The LSAIs acquired vast land areas, including greenfield and brownfield investments. Brownfield refers to developments in areas where there has previously been investment, implying that dispossession of the local population occurred in the past, whereas greenfield refers to developments in areas where no commercial investment has previously occurred, which may result in the dispossession of the local community. (Chu & Phiri, 2015).

LSAIs are not solely determined by the size of the cultivated area but also by the economic scale, which takes into account the capital investments and labour involved (Herrmann, 2016; Osabuohien *et al.*, 2019). It is possible for a LSAI to cover a smaller area, provided it involves a significant amount of capital or employs a significant number of people (Herrmann, 2016). According to Nolte et al., (2016) and Osabuohien, (2014), the term "large-scale agricultural investments refers to the trend of acquiring vast tracts of land through leasing or purchasing by private and public sectors, including emerging economies' governments, for commercial or industrial agricultural production. On the one hand, because of their ability to impact the prospects of broad-based agricultural development, these investments have been the subject of intense controversy in policy and academic debates (Deininger, 2011; Borras Jr and Franco, 2012; White *et al.*, 2012; Hall, Scoones and Tsikata, 2017). For instance, some studies have argued that LSAIs do not contribute to sustainable development as they lead to land alienation, and evictions and eventually destroy the livelihoods of the local community (Baglioni and Gibbon, 2013; Schoneveld, 2017). Alternatively, LSAIs have been touted to be the panacea for inclusive agricultural development when stronger ties exist between these investments and smallholder farmers (World Bank, 2007).

These relationships between smallholder farmers and LSAIs provide incentives that help to secure farmers' produce. The enterprises work with farmers to provide those services in exchange for access to part or all of their produce. Seed, fertiliser, and herbicides are provided on credit as part of the grower programmes; the costs are recovered upon the sale of the produce (Stringfellow, 1996). This is coupled with the provision of extension services through training on different agricultural topics such as ploughing, crop spraying, conservation farming, farming as a business, and savings from agricultural proceeds. Market linkages are created by the establishment of trading depots close to the farmers' proximity to reduce the difficulties faced by smallholder farmers accessing output markets. Out growers work with farmers through Farmer Controlled Groups (FCGs) to enhance cooperation and bulking up in output marketing or storage of crops. Group liability for credit enables individual farmers to reduce lending risks and transaction costs through increased economies of scale (Stringfellow, 1996; Hall, Scoones and Tsikata, 2017).

In addition, LSAIs have become relevant to the local smallholder population as they are a pathway to eradicating poverty (Shutter, 2011). They achieve this by creating jobs and improving the livelihoods of smallholder farming households who often lack secure sources of natural resources (Grover, 2009). They increase food supply and nutritional status through increased agricultural productivity (Fitawek *et al.*, 2020). Large agricultural investments promote infrastructure, increase market accessibility, and provide opportunities for farmers. (Herrmann, 2016; Matenga and Hichaambwa, 2017). They bring about income-generating opportunities in agriculture and increase food security through increased incomes and the distribution of food (Baumgartner *et al.*, 2015). In addition, LSAIs can stimulate agricultural commercialisation through an increased market share of inputs and outputs of the existing agricultural production system (Baumgartner et al.,2015).

This study explores Amatheon Agri Zambia (AAZ). Based in Berlin, Germany, Amatheon Agri Zambia Limited is a European agribusiness firm that was established in 2011 and set up subsidiaries in Zambia, Uganda and Zimbabwe in 2012, 2013 and 2015 respectively (Amatheon Agri, 2015). AAZ started operating in Mumbwa district in 2012, leasing 32,000 hectares of land for 99 years. In 2014, the land was expanded to 38,760 hectares for a brownfield project located in the historic Big Concession Farm block in Mumbwa (Chu and Phiri, 2015; Nolte *et al.*, 2022). Since its founding, it has effectively developed more than 3,000

hectares of land for farming operations that are both rain-fed and irrigated (Amatheon Agri, 2015).

Amatheon has created a thorough out grower programme that provides small-scale farmers with information and access to high-value inputs, credit and a market they need to grow their enterprises and implement risk-reduction techniques (Sakketa *et al.*, 2022). The out-grower programme offers free training in the growing, handling and harvesting of high-value crops (Amatheon Agri, 2018a; Sakketa *et al.*, 2022). The training component includes topics on lime application, herbicide and fertilizer application, post-harvest handling of crops, marketing and accounting which have been termed as 'farming as a business.' AAZ has offered these training services in collaboration with the Conservation Farming Unit (CFU) and World Vision to promote Conservation Agriculture (CA) practices. AAZ used a train-the-trainer approach in offering training to farmers through a lead-farmer technique where experienced farmers were trained by World Vision and CFU. It has demonstrated its capacity to operate on a large scale in Zambia, where it consistently tests new crop varieties and produces resilient yields of soybeans, maize, and wheat (Amatheon Agri, 2018b). It has formalised and expanded trading with farmers by introducing a livestock component where it buys cattle from nearby farmers, fattens them through its feedlot system and sells meat. Amatheon has created a thorough out grower programme that provides smallholder farmers with information and access to high-value inputs.

In 2013, AAZ started trading with farmers in Mumbwa district by buying crops, selling agricultural inputs, and providing extension services (Amatheon Agri, 2013, 2015). AAZ reached approximately 15,000 farmers in 2017 through the "USAID Feed the Future Partnership Innovation" programme when it expanded to a new district, Chibombo, with an extra 6,000 farmers that had training, input, credit and market (Amatheon Agri, 2017). The activity's emphasis on high-value commodities like cowpeas, sunflower, groundnuts and soya beans was a crucial element. Amatheon established a seed bank where farmers were loaned seeds to grow multiply and repay after harvesting (Sakketa *et al.*, 2022).

In addition to Amatheon's three commercial pillars of farming, trade and processing, it has integrated to achieve social impact by promoting entrepreneurship, boosting local productivity and diversifying sources of income (Amatheon, 2018). As part of the trading component of AAZ's programme, it has established trading depots near farmers to allow them to buy inputs and sell their crops at shorter distances.

AAZ's out-grower programme has evolved greatly over the years. In 2019/2020, it supported around 1,000 smallholder farmers to cultivate and harvest Quinoa grains. It guarantees an off-take market through contract farming with farmers around Mumbwa. The company has introduced an additional crop, chilli to its trading component for both international and local markets. It is now focused on quinoa and chia contract farming in Mumbwa while curtailing or discontinuing some of its other activities, mainly the buying of cereals and input support and downscaling to areas closer to its area of operation (Sakketa *et al.*, 2022). It seeks to diversify its portfolios and increase its profit margins by participating in the global market by meeting international standards.

Agricultural commercialisation, according to Pingali & Rosegrant (1995) entails more than only marketing agricultural products, it includes decisions on the use of household goods and the usage of inputs are made by maximizing profits. It has also been defined as increasing the proportion of agricultural production that is sold by farmers and the output side of production with increased marketed surplus or occurs on the input side with increased use of purchased inputs (Jaleta, Gebremedhin and Hoekstra, 2009; Nivas and Waltair, 2015). It is an indispensable way of achieving economic growth as it entails engaging in both input and output markets (increased agricultural productivity, new cultivation methods; new technologies, and introduction of new crops are some potential benefits of agricultural commercialisation) (von Braun, 1995; Timmer, 1997).

1.2 Statement of the Problem

Accessing markets, technology, and resources essential for effective commercialisation is a persistent problem among smallholder farmers, hindering their ability to maximise their agricultural output and economic potential. Despite their crucial role in global food production, smallholder farmers face many challenges in this regard (Chirwa and Matita, 2010). In Zambia, they are known for subsistence farming techniques and primary production of crops like maize, groundnuts, roots, and tubers for home consumption (World Bank, 2007; Schüpbach, 2014; Hlatshwayo *et al.*, 2021). This restrains their ability to grow economically and to both commercialise and enhance overall food security.

Compared to their counterparts, large-scale farmers use cutting-edge inputs, have access to both local and international input and output marketing chains and are strongly tied to agro-processing businesses (World Bank, 2007; Zondi *et al.*, 2022). Smallholder farmers face many challenges stemming from geographical remoteness to inadequate infrastructure which restrict

market access hence limiting their ability to produce more and sell at competitive prices (Herrmann and Grote, 2016). Unlike large-scale farmers, smallholder farmers have insufficient access to modern agricultural technologies, credit, machinery and inputs which reduces their productivity and quality thereby, impeding their competitiveness in the agricultural market (Herrmann and Grote, 2016; Hlatshwayo *et al.*, 2021). In addition, smallholder farmers face information asymmetry when it comes to new agricultural trends, market information and pricing dynamics which hampers their decision-making (Herrmann and Grote, 2016). As if this is not enough, smallholder farmers lack the necessary equipment and infrastructure to scale up commercial agricultural activities due to financial constraints.

Efforts have been made to enhance commercialisation for smallholder farmers. These include interventions such as capacity-building programmes, creation of market linkages, technology dissemination and infrastructure development. However, these initiatives have not addressed these challenges, hence leading to low agricultural commercialisation among smallholder farmers in Zambia. Some interventions include LSAIs which have emerged as potential catalysts for smallholder agricultural transformation (Bottazzi *et al.*, 2018). In Zambia, before the advent of policy reforms in the 1990s, the government made an effort to encourage smallholder commercialisation by establishing agricultural parastatals and providing subsidised inputs and finance (Saasa, 1996).

LSAIs entail large-scale, capital-intensive investments which raises debates about their impacts on surrounding communities. These investments have been found to have positive welfare effects on smallholder farmers especially when they are included in the supply chain (Arndt, Benfica and Thurlow, 2010; Baumgartner *et al.*, 2015). The spill overs of LSAIs include the potential to leverage smallholder farmers' economies of scale, increase productivity and lower production costs. The large agricultural projects set up by LSAIs may lead to improved infrastructure, improved farming practices and advanced agricultural technologies which may benefit smallholder farmers in adjacent communities. On the other hand, scholarly debates have for a long time been made on the negative effects of LSAIs. These include concerns about land-grabbing which results in land tenure issues and displacement of smallholder farmers where these investments are set up (Baglioni and Gibbon, 2013; Lay, Nolte and Sipangule, 2018). In addition, LSAIs pose environmental threats from intensive agricultural activities which may lead to sustainability challenges for surrounding smallholder households (Adewumi, Ayodele and Omotesho, 2013; Baumgartner *et al.*, 2015).

Different studies have been done to ascertain the impact of LSAIs, but none have fully studied the impact of these LSAIs on agricultural commercialisation in Zambia. There is still a dearth of empirical evidence regarding how LSAIs have affected commercialisation among smallholder farmers in Zambia particularly, in Mumbwa and Chibombo districts. With context-sensitive quantitative research, this paper will add something new to the literature. Firstly, the effects of Amatheon Agri, a LSAI on smallholder farmers in Zambia where LSAIs have coexisted with smallholder communities are examined (Chu and Phiri, 2015). Secondly, while assessing the degree of commercialisation using the Household Commercialisation Index (HCI) and how it has evolved, it was interesting to check whether there were any disruptions or shocks that may have affected farmers' levels of commercialisation from 2018 to 2021. The extended time frame spanning from 2018 to 2021 offers a more comprehensive analysis. This longer period allows for observing and understanding the evolution of the impact of Amatheon Agri on smallholder agricultural commercialisation over time, which is a unique aspect that other studies might not have explored.

1.3 Objectives

1.3.1 Main Objective

The main objective of this study was to determine the impact of large-scale agricultural investments on smallholder agricultural commercialisation using the case study of Amatheon Agri Zambia limited in Zambia.

1.3.2. Specific Objectives

1. To assess the level of agricultural commercialisation among smallholder farmers in the Amatheon out grower scheme
2. To examine the key determinants of agricultural commercialisation and
3. To determine the impact of AAZ on smallholder agricultural commercialisation

1.4 Hypotheses

To fully assess the impacts of this LSAI, the study had the following hypotheses:

1. Participants in the LSAIs are more commercialised compared to non-participants.
2. Participation in the LSAIs out grower scheme increases agricultural commercialisation

3. Social, institutional and shock variables determine the level of agricultural commercialisation among smallholder farmers in the AAZ out grower scheme.

1.5 Justification of the study

Assessing the effectiveness of the AAZ out grower program involves evaluating whether participating in it leads to increased agricultural commercialisation. Empirical evidence obtained through hypothesis testing can verify the program's impact in enhancing commercial activities in agriculture. Understanding whether engagement in the AAZ out grower program leads to increased commercialisation can help farmers and potential participants make informed decisions about their participation, adoption of certain agricultural practices, or allocation of resources based on expected outcomes. The study's results can have significant implications for policymakers, agricultural development agencies, and stakeholders involved in the design and implementation of large-scale agricultural support for smallholder farmers. Increased agricultural commercialisation can justify further investment and expansion of similar initiatives to promote economic development in the agricultural sector, while also having broader implications for local and national economic development. Enhanced incomes, job creation, and improved food security often result from increased commercialisation, benefitting both rural communities and the overall economy (Matenga and Hichaambwa, 2017).

1.6 Organization of the Report

Chapters two through five cover the remainder of the report. The literature review illustrating the emergence of LSAIs, several models of the interactions between these LSAIs and smallholder farmers, an analysis of the empirical research on large-scale agricultural investments, and lastly the conceptual framework are covered in detail in chapter two. In chapter three of the study, the data and methods used to achieve the objectives are described in depth. Further, the descriptive and econometric results are in chapter four and the conclusion and recommendations are in chapter five.

CHAPTER TWO - LITERATURE REVIEW

2.1. Introduction

The literature is reviewed to generally highlight the key drivers of LSAIs. The potential relevance of spill overs resulting from large-scale agricultural investments exploring the scholarly debates on the potential impacts of these LSAIs on smallholder farmers has been explained here. In modelling the interaction between LSAIs and smallholder farmers, it is important to understand how they work with these farmers and how they are generally organised. Furthermore, the literature explores the different empirical studies addressing the main questions answered, models of analysis and whether there are any scholarly agreements and disagreements.

The potential for evidence-based policymaking is constrained by the dearth of systematic evidence regarding the impact of these investments on smallholder agricultural commercialisation, although, in theory, investments in massive production units or further up in the agricultural value chain can have extremely beneficial impacts on surrounding smallholder farmers.

2.2 Measures of Agricultural Commercialisation

The interest in comparing households based on their level of commercialisation makes quantifying the level of smallholder commercialisation relevant (Randolph, 1992). Analysing the factors that influence commercialisation and determining the degree to which a particular farm household is commercialised in its entire production, marketing, and consumption decisions are also helpful. To measure the degree of commercialisation, there are several methods or indices (Jaleta, Gebremedhin and Hoekstra, 2009). Commercialisation is measured as a percentage of a household's overall sales or as a percentage of its cash crops relative to all the crops it grows (von Braun, 1995; Von Braun et al., 1994). According to Gebremedhin et al., (2009), the authors have described the forms of commercialisation and integration into the cash economy and have formulated indices to measure the extent of household commercialisation in three different types: The first index calculates the share of market-purchased input and agricultural output that goes towards the overall value of agricultural production. The second type defines commercialisation of the rural economy as the ratio of total household income to the value of goods and services obtained through market transactions. It is assumed that certain transactions might occur in kind, such as paying for land use with food items. The third type calculates the ratio of the total household income to the

value of the products and services purchased with cash to determine how integrated a household is into the cash economy. A household's Commercialisation Index (HCI) was employed by Govereh et al., (1999) and Strasberg et al., (1999) to gauge the degree of commercialisation that was unique to each household. The HCI is calculated as the annual gross value of all agricultural sales divided by the gross value of all crop production for every household.

2.3 The Rise of Large-Scale Agricultural Investments

2.3.1. Drivers of LSAIs

Some of the main factors driving the surge in land acquisitions are growing concerns about food security, the fast rise in the demand for biofuels, and higher returns on agricultural investments. After the peak of the land rush in 2010, approximately 3 million hectares (ha) of deals have been reported in the database; by 2020, 1,865 deals spanning 33 million ha had been recorded (of which 1,560 deals covering 30 million ha have been concluded worldwide) (Lay *et al.*, 2021). Growing interest has been seen in commercial agriculture since the 2000s, which was spurred by the biofuel boom and the global rise in food prices in 2007/2008 led to a global economic slowdown (Cotula and Vermeulen, 2009; Brüntrup *et al.*, 2010; Anseeuw *et al.*, 2012).

The global economic slowdown together with the 2007/2008 global food crisis contributed to undernourishment and food insecurity which prompted importing countries to re-strategise their food supply (Braun, 2008). In an effort to totally escape the volatility of international markets, net importing countries tried to invest directly in food production abroad, while some exporting nations raised prices by imposing export restrictions in order to safeguard their own domestic consumers (FAO, 2008). A report by FAO, (2008) shows that the increasing demand for commodities like vegetables, oils, sugar cane and cereals for the manufacturing of biofuels is another major factor influencing the recent land acquisitions.

Large-scale investments are also influenced by other factors, such as industry demand for agricultural products, policy changes intended to draw foreign direct investment, water shortages and the effects of climate change in home countries, and business opportunities related to rising food prices and land values (Cotula and Vermeulen, 2009).

2.3.2 Spill Overs of LSAIs

The terms of inclusion or exclusion, which specify how much local communities participate in the project, have an impact on how land deals turn out (McCarthy, 2010; White *et al.*, 2012). Therefore, the first interactions between investors and the local population are essential to building trust before starting any project. Locals must be made aware of new investors, but it's also crucial to be honest about the project's prospects, particularly when greenfield investments are being made in predominantly rural areas where they will have a substantial influence on local communities (Nolte and Subakanya, 2016). Locals frequently have a positive outlook on foreign investors and believe they can provide solutions to their community's challenges.

Many African nations made an effort to modernise their agriculture after gaining their independence by promoting large-scale farming and supplying technology, finance, and inputs (Deininger, 2011; Deininger and Xia, 2016). Agriculture was considered a stepping stone to rural development, poverty reduction and employment creation in many of Africa's developing countries (Collier and Dercon, 2014). As a commitment to their Corporate Social Responsibility (CSR), LSAIs may support economic growth and the eradication of poverty by giving local farmers access to high-value markets, modern knowledge, and technology, or by using tax revenues to finance infrastructure, healthcare, and educational projects (Deininger, 2011; Deininger and Byerlee, 2012).

2.3.3. Disagreements/ Land grabs

Widespread concerns and debates have continued about what implications these LSAI have on local communities. These investments have the potential to further marginalise the poor or open up new opportunities to raise living standards in the community, depending on how they are organised (Cotula and Vermeulen, 2009). Some argue that the social and ecological risks of these investments may pose a threat to poor farming local communities with long-term negative impacts (Cotula and Vermeulen, 2009; Hall, 2011; Deininger and Byerlee, 2012; German, Schoneveld and Mwangi, 2013). These negative impacts must be reduced by communicating the trade-offs between the socio-economic and environmental goals to the communities (Nolte and Subakanya, 2016).

On the other hand, these LSAIs may pose potential benefits to surrounding farming households through job creation, access to high-value markets, knowledge and improved technologies (Deininger, 2011; Deininger and Byerlee, 2012). Collier & Venables, (2012) have termed large

investments with huge land deals as “pioneer investors” who produce spill overs through the provision of demonstrative effects such as new technology and labour markets.

Scholars who oppose these large-scale land acquisitions have termed them as “land grabs” as concentration has been given to foreign-owned companies at the expense of indigenous people (Chu, 2010; Hall, 2011; Santos, 2013). It has been observed that it is more difficult for local people to acquire land in Zambia than it is for foreigners (Santos, 2013). Others have added that these LSAIs compete for land with local communities and get about 45% of cropland or vegetation mosaic which contradicts the notion that these investments are focused on “idle or underutilised land,” (Anseeuw *et al.*, 2012). Nations with weak governance systems, land rights issues and hunger and are poorly integrated into the world economy have been a target for these large-scale investments (Arezki, Deininger and Selod, 2011; Schüpbach, 2014).

2.4. Models of interaction between LSAIs and smallholder farmers

According to Cotula & Vermeulen (2009), the type of institutional arrangement is viewed as a crucial factor in how interactions between LSAIs and smallholders turn out. Arrangements that foster connections with smallholder farmers, such as contract farming, nucleus out-grower schemes, or joint ventures combine assets such as technology, capital, markets with land, labour and local knowledge by smallholder farming communities (Deininger and Byerlee, 2012; Herrmann, 2016). Contractual relationships exist between smallholder farmers and large-scale investments to meet the expanding demand for agricultural commodities (Stringfellow, 1996). The conventional logic is that smallholder farmers have a comparative advantage in the production of certain commodities such as cotton and tobacco because their production is labour-intensive (Stringfellow, 1996).

In exchange for various guarantees, inputs, and services, smallholder farmers sell their crops under contract to these private investors for processing or export (Glover, 1990)). Contracts are written during planting season and outline the quantity and price of produce the company will buy at harvest (Glover, 1990; Maertens and Vande Velde, 2017). Payment modalities and some quality specifications such as variety, impurity and humidity thresholds are specified in the contract and the right to reject substandard produce from farmers at the time of harvest (Maertens and Vande Velde, 2017). The company or investment provides inputs such as seeds, fertiliser, credit, farm machinery rentals and technical advice throughout the growing season (Glover, 1990, 1984; Maertens and Vande Velde, 2017). Glover, (1990) further explains that

output contracts have inbuilt credit schemes such as tripartite arrangements with commercial banks and farmers use their output contracts as collateral for credit received from these investments.

2.5 Empirical studies on the impact of LSAIs

Since most studies have focused on large-scale farms that have amassed the majority of the land in various African countries, there has been minimal focus on smallholder farmers who are making the shift to medium-scale farming (Matenga and Hichaambwa, 2017). The study demonstrates that the agricultural sector is highly heterogeneous in Ghana, as it is in most other African nations, as demonstrated by differences in farmers' degrees of asset ownership and agricultural commercialisation, as well as differences in their resource bases, initial farm sizes, input utilisation levels, and technological adoption (Chapoto, 2013). In Mkushi, three distinct models of economic agriculture were analysed: a plantation, a billboard farming area, and an out grower scheme. The results showed that smallholders who had previously owned larger land were only permitted to carry a maximum of six hectares and that they were compelled to encroach on pastoral land because this land was used as homes for out-growers who were relocated to make way for block farming (Matenga and Hichaambwa, 2017).

According to Bottazzi et al., (2018) impression study of the biofuel environment in Sierra Leone, farmers in the LSAI area have reduced the amount of land they use for food production, are getting lower yields, and would prefer to spend more on outside labour. In evaluating the impact of an investment whose participants were foreign nationals, Baumgartner et al., (2015) showed that while forest resources are crucial for a variety of rural impoverished groups, the gains from the creation of jobs and new business opportunities usually outweigh the losses. Their model made use of extensive quantities of primary data that were gathered in 2010–2011 at the location.

According to Schüpbach (2014), the majority of smallholder farmers enter into contractual agreements as a result of their limitations, which force the development of out-grower programs. According to the research, when local commercial farms cannot supply demand and transaction costs are low because of efficient small-scale farmer groupings, large-scale processors rely on small farmers. Another alternative for small-scale farmers to tackle their problems is to participate in contract farming programs run by commercial food processors or marketing agencies.

The study analysed the effects of large-scale agricultural investments (LSAIs) in sugar and rice on household welfare in Tanzania (Herrmann, 2016). A comparison was made between out grower participants and non-participants regarding the impact of LSAIs on household incomes and income poverty in Kilombero District, which is a priority cluster for Tanzania's Southern Agricultural Growth Corridor (SAGCOT). The study results indicate that participants of the investments had overall positive household welfare compared to the respective counterfactuals. However, the welfare effects varied greatly between different arrangements and subsectors. Out-grower participants had the largest estimated effects, with land-rich out-growers benefiting more than land-poor out-growers. Although land-poor workers appeared to benefit from both schemes, the benefits for agro-industry workers in the sugar investment were noticeably greater than those in the rice investment. Thus, the research indicates that wage work in the agro-industry and out-grower programmes may be able to assist the land poor in escaping extreme poverty. The study does, however, also emphasise the necessity of addressing the difficulties experienced by outgrowers who lack land. According to qualitative interviews, there is an increasing risk of elite capture by larger out-growers for land-poor out-growers (Herrmann, 2016).

2.6 Conceptual Framework

The relationships between LSAIs and smallholder farmers, as well as the possible effects of these investments on the local communities and contractual agreements involved, are depicted in Figure 1. Along with the three AAZ treatment arms that determine participation in the out grower scheme, it also includes the interaction of important variables. Important aspects of smallholder households, such as wealth, event shocks, farm level, and socioeconomic factors, are covered. Examples of household characteristics include the head of the household's age, gender, and level of education, as well as the composition of the household. Farm-level parameters include variables like farm size, planted area, and harvested quantity. Shocks include pandemic, weather and market shocks. The distance to Amatheon, credit availability, membership in cooperative groups, and ownership of agricultural assets are examples of institutional and wealth factors. In the end, these exchanges between LSAIs and smallholder farmers with consideration of these key variables of interest determine the adoption, success and impact of LSAIs on smallholder farmers' livelihood and commercialisation.

The interactions between LSAIs and smallholder farmers are depicted in Figure 1, including important variables that illustrate how the commercialisation of agriculture is related to one

another. Socioeconomic, agricultural, market, wealth, and exogenous conditions and shocks are among the variables of interest. The age of the household head, sex, degree of education, and size of the home are examples of socioeconomic characteristics. Farm size, the area planted, the quantity harvested, and the quantity sold are all considered farm-level variables. Institutional and market factors include variables like pricing information, cooperative membership, and market distance. The above elements have an impact on market participation, including its level. As a result, market participation, along with the degree of participation and the choice of profitable market choices, facilitate the commercialisation of agriculture and contribute to higher household incomes.

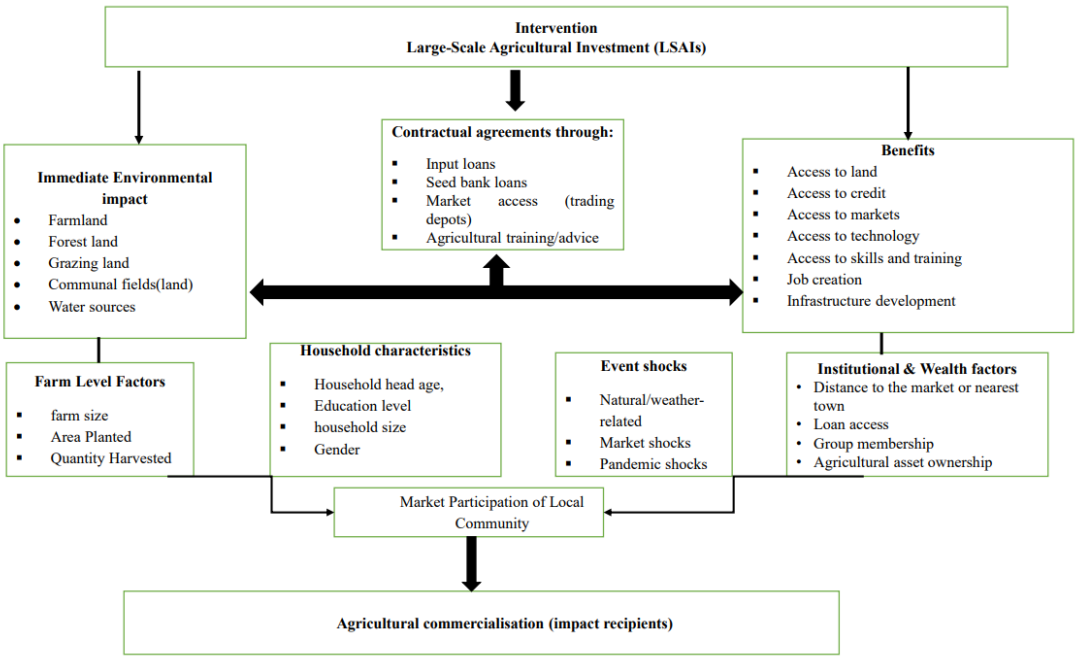

Figure 1: Conceptual Framework of the interaction of LSAIs and smallholder farmers
Source: Author's compilation based on literature

In summary, the study builds upon existing research by employing a context-sensitive quantitative approach to evaluate the impact of a specific LSAI, Amatheon Agri, on smallholder farmers in Zambia. The inclusion of the HCI index likely helps in assessing how involved smallholder farmers are in commercial agricultural activities which could be influenced by AAZ. A more extended study period adds depth and nuance to the research, allowing for a more comprehensive understanding of the effects of this agricultural investment on local commercialisation patterns.

CHAPTER THREE - METHODOLOGY

3.1. Introduction

This chapter presents the methods and procedures used to achieve the study objectives. It discusses the data type, sources and methods as well as the econometric models used to assess the impact of AAZ on smallholder agricultural commercialisation in Zambia.

3.2. Study Area and Data Collection

The study uses secondary data on the Impact Evaluation of the Amatheon Agri Zambia (AAZ) out grower scheme for both the baseline and end-line survey. The research uses cross-sectional data collected sequentially between 2018 and 2021 in Chibombo and Mumbwa districts of Central Zambia and compares the changes across the two study periods. In contrast to other studies, this study uses AAZ out grower scheme data spanning many years and controls for unobserved heterogeneity. Figure 2 below shows the location map of the two study areas.

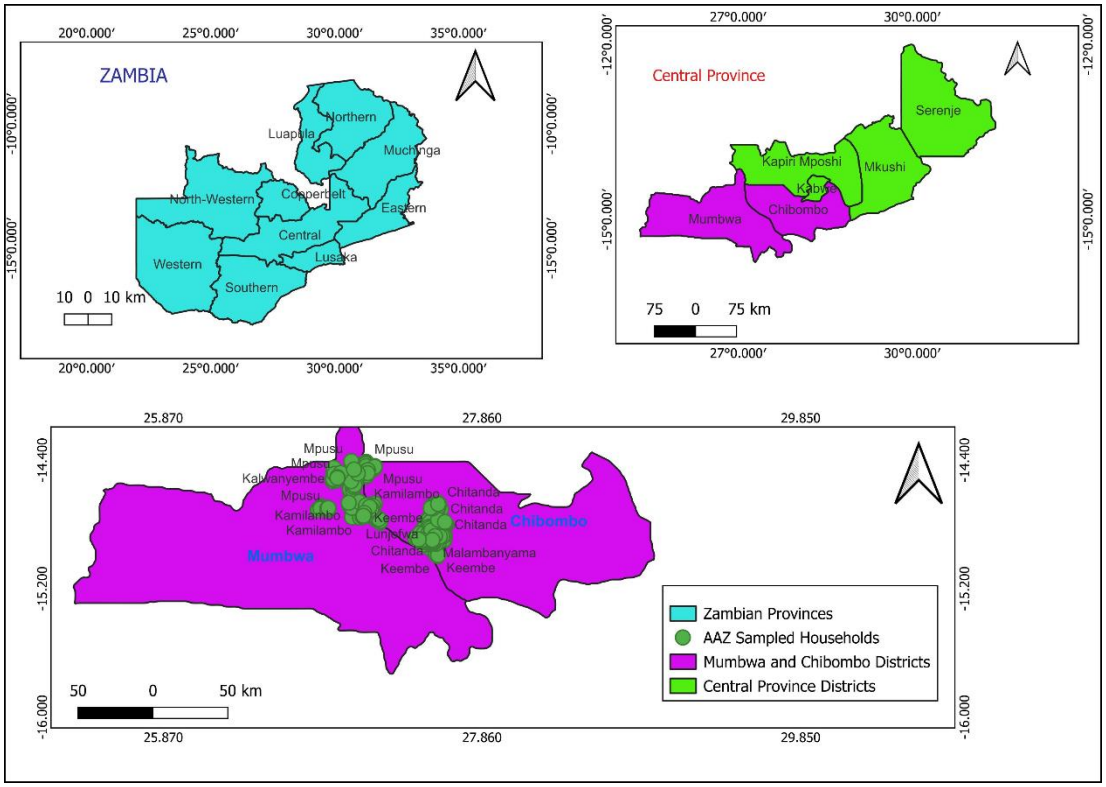

Figure 2: Location Map of Mumbwa and Chibombo Districts
Source: Author's design using QGIS version 3.32.2

Data was collected by the University of Zambia (UNZA) and the Deutsche Institut für Entwicklungspolitik (DIE) German Development Institute (GDI) together with the Leibniz University of Hannover. Household survey questionnaires were administered using Computer Assisted Personal Interviews (CAPI) guides to households with farming experience on their

farm and household type, production and sales of crops and livestock as well as income-generating activities the households participated in.

To determine the baseline in 2018, the survey used a multi-stage sampling technique. FCs served as the primary sampling units in a given area and managed the lists of participating farmers in the AAZ intervention. Subsequently, the research team selected participant and non-participant households from the lists created by the FCs and village authorities. The team chose 28 FCs at random who operated in 103 villages out of an original list of 80 FCs that were actively operating in both districts. There were 53 villages with 1,369 registered farmers (1,284 households) after up to three villages per FC (biggest, lowest, and a medium-sized village in terms of participation count) were chosen. In 2018, 797 households were interviewed focusing on the 2016/2017 agricultural farming season and the follow-up study was conducted in 2021 with a focus on the 2019/2020 agricultural farming season. During the follow-up study, locating the households interviewed at the baseline survey was difficult. We had a total of 690 households, including 100 additional quinoa households that are not the focus of this study. Of the 797 baseline households, 206 households were not re-interviewed in 2021 due to migration, non-contact and death. This resulted in a high attrition rate of about 25%. Therefore, we ended up with 590 balanced panel households, which is this study's focus sample. A high attrition rate in two-wave studies may cause bias in our estimates hence, we checked for systematic differences in household characteristics, wealth indices, crop production, kinship ties and programme components. Table 1 results show that there were no significant differences between the attrited and balanced panel households in terms of the three treatment arms of AAZ. Systematic differences were observed in a few factors such as household size, maximum education levels of non-decision-making members, agricultural assets, land size and access, and kinship ties. Attrited households have smaller household sizes, lower levels of education for any household member and appear to be poorer than the balanced households in the sample. This is seen in the lower maize and soya bean yields, lower landholding sizes and lack of agricultural and transport assets such as a tractor, oxen and a motorbike.

Table 1: Systematic Differences between Attrited and Balanced Panel Households

	Attrited households		Balanced panel households		
Variable	**Obs**	**Mean 1**	**Obs**	**Mean 2**	**Difference**
Household characteristics					
Dummy=1 if married heads	206	0.811	582	0.826	-0.016
Female-headed household, 1=Yes	206	0.165	582	0.170	-0.005
Age of household, years	206	43.583	582	44.610	-1.027
Household size	206	6.456	582	7.112	-0.66**
Heads education, years	206	7.398	582	7.405	-0.007
Maximum education for any hh member, years	206	9.150	582	9.201	-0.051*
Wealth indices					
Agricultural index (PCA) including tractor/oxen	206	-0.317	582	0.103	-0.4199
Agricultural index (PCA) only tractor/oxen	206	-0.196	582	0.063	-0.260**
Agricultural index (PCA) w/o tractor/oxen	206	-0.239	582	0.078	-0.317*
HH wealth index (PCA) including motorbike/cars	206	-0.226	582	0.083	-0.309*
HH wealth index (PCA) without motorbike/cars	206	-0.228	582	0.087	-0.315*
Dummy=1 if hh irrigated any field	206	0.000	582	0.002	-0.002
Dummy=1 if household experienced any shock in the past 5 years	206	0.660	582	0.727	-0.067
Loan access from other sources other than AAZ	206	0.274	582	0.278	-0.0035
Treatment components					
Treat_1.received training/advice from AAZ	206	0.553	582	0.575	-0.021
Treat_2 acquired an input loan from AAZ	206	0.316	582	0.326	-0.011
Treat_3 sold grain to AAZ	206	0.214	582	0.231	-0.017
Treat_4	206	0.233	582	0.260	-0.027
Crop production					
Maize Yield, Kg/ha planted	195	2102.979	571	2299.144	-196.165*
Soya Yield Kg/ha planted	160	1427.188	465	1558.358	-131.170*
Total Crop ha	206	3.385	581	3.750	-0.365
Per capita farm size	190	0.786	527	0.762	0.024
Landhold size	206	4.874	582	4.979	-0.105**
Land acces~c	199	0.786	548	0.764	0.022*
Kinship Ties					
ha_customa~d	196	5.827	538	7.014	-1.187
Kinship ties with the Chief	206	0.038	582	0.087	-0.049**
Kinship ties with the headman	206	0.371	582	0.463	-0.092*
Kinship ties with the FC	206	0.314	582	0.379	-0.065

*** p<0.01, ** p<0.05, * p<0.1
Source: Author's compilation

3.3 Data Analysis

STATA 14 and MS Excel software programmes were used in the study to analyse the data. The econometric analysis was conducted using the STATA 14 (2015) tool, while the graphs and tables were created using the MS Excel package.

3.3. Explanatory Variables in the Regression Model

3.3.1. Household Social economic factors

Age of household head: the household head is the ultimate decision-maker and plays a significant role in making serious family decisions that include resource distribution, choice of crops to be grown and what crops should be marketed (Martey, Al-Hassan and Kuwornu, 2012; Mwiinga, 2021). In agricultural production and marketing, a farmer's age serves as an indication for their level of farming knowledge and experience. It is a continuous variable with a time scale of years, and its impact on market participation is predicted to be either positive or negative (Madududu *et al.*, 2022). While younger farmers are thought to be more enthusiastic, open to new ideas, and aware of the advantages of agricultural commercialisation, they are expected to use their farming experience to increase crop production and find better markets for their produce. As a result, they are expected to be more involved in agricultural marketing than their older counterparts (Randela, Alemu and Groenewald, 2008; Chilimboyi, 2021). Madududu et al., (2022) observed that agricultural commercialisation was strongly influenced by the household head's age, but Mutami, (2015) found that there is a negative correlation between the household head's age and commercialisation, with younger farmers being more likely to commercialise than older ones.

Household head level of education: this continuous variable, expressed in years, represents the household head's formal school years. It has been shown that higher education levels improve competency and the effective use of enhanced production, processing, and marketing strategies (Mango *et al.*, 2018; Chilimboyi, 2021). Previous research indicates that a farmer's decision to engage in the pineapple market was positively influenced by their level of education (Geoffrey *et al.*, 2013). Chilimboyi (2021) showed that revenues from the sale of mixed beans increase by 2.48 kg for every year that an individual's education increases, *ceteris paribus* while Mango et al.,(2018) argues that having more education provides an advantage for one's capacity to comprehend and analyse agricultural extension information and as a result, an increase in the amount to comprehend the amount of production surplus available for sale. In addition, younger farmers have more education and interaction with the outside world. The

majority of older farmers have a deep emotional or even biological bond with farming and the land; they see it as a way of life rather than a business (Randela, Alemu and Groenewald, 2008). Education increases a person's propensity to cooperate with others and take part in group activities while also empowering them to make independent decisions and act accordingly (Martey, Al-Hassan and Kuwornu, 2012). The household head's level of education may also improve the likelihood that the household head will earn a non-farm income which might lessen the dependence of the household on agriculture and hence on commercialisation (Martey, Al-Hassan and Kuwornu, 2012).

Household size: This is a continuous variable that shows how many people live in the same household. It is expected that households with larger households will be more likely to participate in commercialisation due to the greater supply of home labour that may be valuable in farming activities, especially during intense farming activities such as crop cultivation (Rubhara and Mudhara, 2019). Randela et al., (2008) found that consumer and production patterns are influenced by household size, which also has a bearing on market participation. The author further found that a larger household size might discourage consumers from selling surplus because the household requires the produce for consumption. Commercialisation may be both negatively and positively impacted by household size. Large households can provide labour for cassava operations in the first scenario, which is known to be labour-intensive and helps to lower the cost of labour. On the other side, a barrier to commercialization could be the larger household size. This is due to the possibility that it may boost diversification into other sectors while also reducing the surplus of cassava that can be sold (Onya *et al.*, 2016).

3.3.2. Farm Level Factors

Farm Size: this variable is measured in hectares and has been found to influence agricultural commercialisation. Farm size may affect the volume of sales by a household, (Martey, Al-Hassan and Kuwornu, 2012) found that farm size significantly influenced maize and cassava market participation

Area Planted: The area that the farmer has allotted to both maize and soya beans is a continuous variable. As the area planted grows, it is anticipated that the likelihood of participation in the market will rise (Rubhara and Mudhara, 2019). It is anticipated that a farmer who expands the area planted may eventually have surplus production therefore, it is anticipated that the variable will have a favourable impact on the farmer's level of market participation (Chilimboyi, 2021).

Quantity Harvested: This continuous variable has a unit of measurement of kilogrammes (kg). How much of a crop is ultimately sold to the market and the level of market involvement is determined by the amount of the crop that is produced (Olwande and Mathenge, 2011). According to Onya et al., (2016), the amount of cassava produced had a significant effect on how many people participated in the garri market.

3.3.3. Market and Institutional Factors

Loan access: this is a dummy variable indicating the farmer's capacity to obtain loans from formal and informal sources for agricultural uses. The value taken is one if the farmer has access to loans, and zero otherwise. In the AAZ scheme, most loans were seed bank loans for cowpeas and sunflower and input loans for maize and soya beans. Studies have shown that access to credit helps to cushion smallholder farmers' financial constraints (Olwande and Mathenge, 2011; Sakketa *et al.*, 2022). Krishnankutty & Krishnan, (2013) revealed that credit facilities to smallholder farmers were significant in the transition from subsistence to commercial farming. Access to loans enables farmers to generate production surpluses, reduce postharvest losses and thus, increase commercialisation (Sindi, 2008). Low access to loans may limit smallholder farmers' ability to access inputs to improve their production thus hindering their participation in markets (Olwande and Mathenge, 2011).

Access to information: Households must have access to market opportunities in order to better their financial situation. But in order to take advantage of these chances, you need information as well as credit. The inability of poor households to obtain the requisite social capital can impede their capacity to engage in the market and enhance their financial circumstances. Consequently, improving the social capital is crucial to improving their access to markets. Through establishing social networks and connections with other people and institutions, impoverished households can obtain important knowledge and resources required for engaging in the market (Olwande and Mathenge, 2011). In the long run, this can improve their financial status by enabling them to invest in their businesses and help them establish credit and trust with possible lenders (Kirsten *et al.*, 2009).

Distance to the market or nearest town: this is a continuous variable measured in kilometres (km). In this study, the variable indicates the distance between the farmer's homestead and the nearest town, we use Lusaka, Mumbwa and Chibombo as they have the biggest buyers in these towns. We also capture the distance to the nearest market which is the Amatheon trading depot.

It is expected that longer distances increase travel time and travel costs, which impact market participation negatively (Olwande and Mathenge, 2011)**.**

3.3.4. Wealth factors

Asset ownership: this represents a common form of savings and investment among households in rural areas. A household's tractors, oxen, ploughs, livestock, fixed assets and landholdings are a good indicator of its wealth and productive potential (Hailua *et al.*, 2015; Endalew *et al.*, 2020). It is expected that wealthier households will invest in higher income-generating enterprises.

3.3.5. Event Shocks

Event shocks can disrupt agricultural production, reduce incomes, and increase uncertainty. This can make it more difficult for farmers to invest in commercialisation and can lead to a decrease in agricultural commercialisation**.**

Natural or Weather-related shocks: these include floods, unusual timing of rainfall, droughts or dry spells during the season, bushfires and windstorms and biological shocks such as crop pests and diseases. These are considered production shocks as they could affect agricultural production and could lead to crop losses, loss of productive agricultural assets such as livestock and eventually loss of income (Agamile, Dimova and Golan, 2021).

Marketing shocks: these are strong price increases for agricultural inputs, strong price decreases for agricultural outputs, strong inflation which increases food prices and prices of other commodities, and the collapse of a business by a household member. These marketing shocks could impede agricultural commercialisation and lead to lower produce prices, loss of income and low-quality products (Salazar, Ayalew and Fisker, 2019).

Pandemic shocks: shocks such as illness of a household member due to COVID-19, illnesses due to other reasons, death of a household member due to COVID-19 or other reasons affecting both agricultural productivity and commercialisation. The effects of these shocks can lead to loss of income as the household may have less productive manpower to contribute to the generation of income and thus, may not produce enough for the market. Pandemic shocks can also increase uncertainty for farmers, making it more difficult to plan for the future and invest in commercialisation (Morton, 2020). These shocks can also disrupt supply chains, making it difficult for farmers to get their products to market. This can lead to price volatility and make it more difficult for farmers to sell their products at a profitable price (Béné, 2020).

3.3.6. Treatment components

The treatment arms are; the household received training or agricultural advice from AAZ (T_1), the household received input/seed bank loan from AAZ (T_2), the household sold any grain to AAZ(T_3), and if the household participated in either of the three treatment arms (T_4). The farmers are characterised as participants and non-participants. Participation in the AAZ out-grower programme means that a farmer received advice or training on any agricultural topic from AAZ, sold or bought grain to or from AAZ, received an input loan, or participated in either of the three treatment arms of AAZ. The households that received agricultural advice or training from AAZ are classified under treatment arm one(T_1). These households received free training from Amatheon for at least one agricultural season between 2013/2014 and 2020/2021 on various topics such as crop cultivation, postharvest handling, Conservation Agriculture (CA), input use, farming as a business, and sustainable land management practices. Individuals who received input support from AAZ in at least one agricultural season between 2013/2014 and 2020/2021 are classified under treatment arm two(T_2). Likewise, treatment arm three (T_3) includes households that sold grain to AAZ in at least one season between 2013/2014 and 2020/2021 through its guaranteed off-take market of harvested crops. The general treatment(T_4), represents households that participated in any of the three treatment arms (T_1), (T_2) and(T_3). Households in the comparison group (C) are those that took part in none of the of the three treatment arms from the beginning of AAZ in 2013/2014 until the time when AAZ restructured its out grower scheme in 2019/2020 to focus more on cash crops such as quinoa and chilli.

Table 2: Description of variables used in the Fractional regression.

Variable	Description	Expected sign
Household characteristics		
HH age	Age of the household head in years	+/-
Head is married	=1 if the household head is married	+/-
Female-headed household	=1 if the household head is female	+/-
Household head education HH (head)	Formal years of education of the household head	+
HH size	Number of household members	+
Crop Production		
Total cultivated crop, ha	Total cultivated land for crop production (in hectares)	+
Cultivated maize, ha	Total cultivated land for maize (in hectares)	+
Cultivated soya beans, ha	Total cultivated land for soya beans (in hectares)	+
	Distance to Lusaka in kilometres	-
Distance nearest town market	Distance to Mumbwa in kilometres	-
	Distance Chibombo in kilometres	-
	Distance to AAZ depot in kilometres	-
Wealth indices		
Agricultural asset index including oxen/tractor	Agricultural asset index computed using pca, including tractor/oxen	+
Agricultural assets including oxen/tractor/plough	Agricultural asset index, only tractor/oxen plough (using pca)	+
Agricultural asset index without oxen/tractor	Agricultural asset index, without tractor/oxen	-
HH wealth index including motorbikes/cars	HH wealth index (pca), including motorbikes or cars	+
HH wealth index without motorbikes/cars	HH wealth index (pca), without motorbikes or cars	-
Variables related to shocks or disruptions		
HH experienced a shock	=1 if a HH experienced a shock in the past five years	-
Most severe shocks index	HH with severe shocks index computed using pca	+/-
Programme Components (treatment arms)		
Received training/advice from AAZ (T_1)	T_1 if a household received agricultural training or advice from AAZ	+
Acquired input or loan (T_2)	T_2 if a household acquired an input or seed bank loan	+
Sold grain to AAZ (T_3)	T_3 if a household sold any grain to AAZ	+
Either T_1, T_2 or T_3 (T)	If a household participated in either treatment arms	+

Source: Author's compilation

3.4. Empirical Approach

3.4.1 Household Commercialisation Index

To achieve objective one, commercialisation indices as the outcome variables were used to assess the level of agricultural commercialisation among smallholder farmers. AAZ constructed trading depots in communities to buy crops from smallholder farmers, such an intervention might have an impact on how well farmers participate in markets. Household Commercialisation Indices (HCI) for maize, soybeans and crop commercialisation were calculated to reflect such an effect. The building of depots may make it simpler for out-growers to access markets, which could have an impact on farm gate prices.

$$HCI = \frac{Gross\ value\ of\ crop\ sales\ in\ i\ _{year\ j}}{Gross\ value\ of\ all\ crop\ production\ in\ i_{year\ j}} \times 100$$

The commercialisation index, which measures households' market participation: is computed by dividing kg sold by kg harvest (Govereh, Jayne and Nyoro, 1999). This index reflects how much domestic crop production is focused on the market. A household with an index value of zero would be entirely subsistence-oriented, whereas a household with an index value of 100 would be entirely commercialised (Dube & Guveya, 2016; Govereh et al., 1999). Hence, it also measures the intensity of market participation. For instance, the maize commercialisation index is computed as maize revenue (the price of maize per kg multiplied by kg sold) divided by maize value of production (the price of maize per kg multiplied by kg of maize harvested) (Jaleta, Gebremedhin and Hoekstra, 2009). The advantage of this method is that commercialisation is considered a continuum, preventing the arbitrary division of households into "commercialised" and "non-commercialised" groups (Martey, Al-Hassan and Kuwornu, 2012). The construction of the soybean and total crop commercialization indexes follows a similar process.

The levels of agricultural commercialisation were classified as low (< 30%), medium (30% 75%), and high (> 75%) following the categorisation by Amfo et al., (2022) and Asuming-Brempong, 2(013).

3.4.2 Fractional Regression Model

This study uses the fractional logit regression model to achieve objective two; analysing the determinants of agricultural commercialisation in the AAZ scheme as it assumes a logistic

distribution of the error term. The dependent variables in this study are maize, soya beans and overall crop commercialisation indices.

Previous studies have used the Tobit and Multiple regression models to examine the determinants of agricultural commercialisation, but these are ineffective for quantifying commercialisation as they do not consider its bounded nature (Endalew *et al.*, 2020). The error term in multiple regression is assumed to be normally distributed and homoskedastic, however, this assumption does not hold for bounded variables. The Tobit model is similarly not the appropriate measure for commercialisation since agricultural commercialisation as an index score includes the upper and lower predicted values of proportions (0,1) (Papke and Wooldridge, 1996; Gallani, Krishnan and Wooldridge, 2015). In trying to control this, other studies have used the Beta and Zero-inflated Beta regression, but these models exclude excess zeros suggesting a separate process leading to zero outcomes (Swearingen, Melguizo and Bursac, 2012; Meaney and Moineddin, 2014). In order to capture the absolute lower and upper bounds of such an outcome variable, the Fractional regression model is more appropriate i.e. values between 0 and 1 including the actual 0 and 1 unlike the Beta regression model (Abonazel *et al.*, 2022). In contrast to the beta regression model, fractional response models are useful, for example, when the outcome variable contains values between 0 and 1, including the actual 0 and 1. i.e., $0 < y < 1$ (Abonazel *et al.*, 2022). In order to prevent model misspecification and maintain statistical validity, two models are utilised: fractional response and beta regression. These models reflect nonlinear interactions between the fractional outcome and exogenous factors. (Baum, 2008; Endalew *et al.*, 2020). However, to account for excess zeros in the model, the Fractional regression is more applicable if the dependent variable is in the form of a fraction, rates, proportion, indices, or probabilities. The fractional regression model is based on the assumption that the dependent variable can be continuous or discrete, exhibit heteroscedasticity, or when there is excessive clustering around the boundary values (Meaney and Moineddin, 2014).

Continuous dependent variable y (HCI) in [0, 1], and a vector of independent variables (x). Fitting a regression for the mean of y conditional on x: $E(y/x)$ and because y is in$[0,1]$, we restrict that $E(y/x)$is also in$[0,1]$, hence, the fractional logit model is specified as:

$$Exp(y|x) = \frac{exp(x\beta)}{[1 + exp(x\beta)]}$$

Where

$$Y\ is\ the\ HCI, 0 \leq HCI \geq 1$$

X is a vector of explanatory variables explained by a 1×k vector: $x = (x_1, x_2, \ldots, x_k)$

Dependent Variables

Maize commercialisation index: this is a continuous variable calculated as the (price of maize per kilogram multiplied by the kg sold) divided by maize value of production (price of maize per kilogram multiplied by a kg of maize harvested).

Soya beans commercialisation index: this is a continuous variable calculated as Soya beans revenue calculated as the (price of Soya beans per kilogram multiplied by the kilogram sold) divided by Soya beans value of production (the price of Soya beans per kg multiplied by a kilogram of Soya beans harvested).

The overall crop commercialisation index is a continuous variable: calculated as the (price of crop per kilogram multiplied by the kg sold) divided by crop value of production (price of crop per kilogram multiplied by a kg of crop harvested). Groundnuts, cowpeas, sunflowers, fruits and vegetables are used to calculate the crop commercialisation index.

3.4.3 Principal Component Analysis

3.4.3.1 Shocks Index

To create an event shock variable index, the study applied the Principal Component Analysis (PCA) technique for possible shocks that a household may have faced. The shocks index was used in the Fractional regression to analyse the determinants of smallholder agricultural commercialisation. Different tests were conducted on the data before carrying out the PCA test. To check for the sampling adequacy, the Kaiser-Meyer Olkin (KMO) test was employed as it is suited for factor analysis. The KMO test measures how correlated variables in the model and the proportion of variance among variables, it is mathematically represented as:

$$MO_j = \frac{\sum_i \neq j {r^2}_{ij}}{\sum_i \neq j {r^2}_{ij} + \sum_i \neq j u}$$

Where: R= correlation matrix

U= partial covariance matrix and

∑= summation notation

The KMO value is a number between 0 and 1, with values between 0 and 0.49 deemed "unacceptable," between 0.5 and 0.59 deemed "miserable," between 0.6 and 0.69 deemed "mediocre," between 0.7 and 0.79 deemed "middling," between 0.8 and 0.89 deemed "meritorious," and between 0.9 and 1.00 deemed "marvellous." A high KMO indicates a strong correlation between the variables, indicating that factor analysis is probably the best course of action. The Bartlett's test of Sphericity was conducted to test for the strength of the relationship among shock variables and test the null hypothesis that the original correlation matrix is an identity matrix. The matrix correlation of variables and the individual KMO values are shown in Appendices 1 and 2 respectively.

The output shows that the overall KMO value is 0.763 which is above 0.7 indicating that the shock variables are well-correlated and are appropriate to create a PCA index. Results from Bartlett's test show a high significant level of 0.000 as shown in Table 3 indicating sufficient evidence to reject the null hypothesis. It can thus be concluded that the correlation matrix is spherical and the variables are suited for the PCA index.

Table 3:Kaiser-Meyer-Olkin measure of sampling adequacy and Barlett's Test of Sphericity

KMO sampling adequacy	Bartlett's Test	
0.763	Determinant of the correlation matrix	Det=0.208
	Chi-square	903.733
	Degrees of freedom	36
	p-value	0.000
	H_0: variables are not intercorrelated	

Source: Author's compilation

To create the PCA index, we used the Eigenvalue test and the scree plot to retain components that are above 1.00. Table 4 and Appendix 4 show these results and we estimated factor score coefficients. The two-factor scores account for 47.48% of the total variance in the dataset while the individual scores accounted for 32.38% and 15.10% respectively. Then, a PCA index was created using the two-factor scores which are used in the regression to determine whether agricultural commercialisation was affected by any shocks or disruptions.

Table 4: Total Variance Explained by the PCA Components

Component	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Comp1	2.5908	1.3829	0.3238	0.3238
Comp2	1.2079	0.2446	0.1510	0.4748
Comp3	0.9633	0.0323	0.1204	0.5952
Comp4	0.9309	0.1963	0.1164	0.7116
Comp5	0.7346	0.1208	0.0918	0.8034
Comp6	0.6138	0.0472	0.0767	0.8801
Comp7	0.5667	0.1762	0.0708	0.9509
Comp8	0.3920	.	0.0490	1.0000

Source: Author's compilation

3.4.3.2 Household wealth indices

To rank households fairly and objectively, it is important to compare different forms of assets. This requires normalizing the assets by constructing indices scaled from 0 to 1 for each asset. These indices are then combined to create an aggregate index, which is used for ranking the households. The scaling process used is similar to the approach described in Freeman et al. (2004), where the indices are scaled from 0 to 1.

$$i = \frac{x_l - x_{min}}{x_{max} - x_{min}}$$

Where i is the index, x_l is level while x_{min} and x_{max} are the minimum and maximum values of $x$taken from the data. Once scaled (or normalised), the indicators can be added together without the element of distortion which would be introduced by widely differing value ranges. With the normalised indices, PCA techniques (Langyintuo and Mungoma, 2008) were used to extract from a set of variables those few orthogonal linear combinations of the variables that capture the common information most successfully. Intuitively the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information that is common to all of the variables. From the normalised indices and PCA output, an overall 'wealth index', for each household was constructed by applying the following formula:

$$W_j = \sum_{i=1}^{k} [b_i(a_{ji} - x_i)]/s_i$$

Where: W_j is the standardised wealth index for each household b_i represents the weight assigned to (k) variables on the first principal component, a_{ji} is the value of each household on each of the k variables, x_i is the mean of each of the k variables and s_i is the standard deviation. A negative (-W_j) implies that relative to the communities' measure of wealth, the household is poorly endowed and hence worse off while a positive value of W_j means that the household is well off. A zero value of W_j means that the household is neither worse off nor well off (Kalinda *et al.*, 2014).

3.5.1 Propensity-Score Matching (PSM)

To achieve the third objective, the study employed the Propensity Score Matching (PSM) to measure the impact of AAZ on smallholder agricultural commercialisation. PSM assesses the average difference in the outcome variable between the two groups by matching each participant with an identical non-participant (Khandker, B. Koolwal and Samad, 2009). Determining the counterfactual outcome basically, what would have happened to participants if they had not received the treatment is difficult when developing a convincing impact evaluation. The counterfactual outcome must be estimated using statistical techniques because it cannot be directly observed (Heinrich, Maffioli and Vázquez, 2010). One specific non-experimental evaluation method is Propensity-Score Matching (PSM) which calculates what would have occurred to the treated group in the absence of the intervention using units from

the untreated group in an intervention. This is accomplished by contrasting how the treated group's results and those of the untreated group differ.

Participation in the AAZ scheme is non-random as participants self-select themselves into the programme causing a problem of endogeneity making the treated and control groups have systematic differences in treatment outcomes.

It is crucial to note that the baseline survey was carried out two years after the intervention had begun to run. Additionally, several interventions were in their final year or were still in progress when the follow-up survey was carried out. Except for the quinoa component, which had only recently begun, the main out grower initiative concluded in 2019 or 2020. It is noteworthy that some participants had already been exposed to at least one treatment arm of AAZ activities since the intervention began back in 2014/2015 when baseline data was being collected in 2018. These included loaning out inputs, selling grain to AAZ, and obtaining training on a variety of agricultural topics. Assessing the impact of participation in AAZ activities on agricultural commercialisation can be challenging since there is no true baseline. However, using Propensity Score Matching (PSM) can help reduce potential bias resulting from self-selection into the programme. The Kernel weight is used to measure the effects on the counterfactuals instead of discarding the unmatched individuals from the matching between treated and control groups. One advantage of the Kernel matching is that it is precise as it retains the sample size without worsening bias (Garrido *et al.*, 2014). The Kernel Density estimator was used to obtain smooth scores for both the treated and control groups with areas of zero density having positive density estimates (Nichols, 2007).

PSM analytically is represented as:

The impact of AAZ treatment on individual *i*, noted δ_i, is defined as the difference between the potential outcome in the case of treatment and the potential outcome in the absence of treatment:

$$\delta_i = Y_{1i} - Y_{0i}$$

To calculate the average impact of AAZ on commercialisation, we use the Average Treatment Effect (ATE) by taking the mean difference in outcomes across the treated and control groups. We employ the Average Effect on the Treated (ATT) using non-experimental techniques with panel data:

$$ATE = E(\delta) = E(Y_1 - Y_0)$$

Where,

$E(.)$ *represents the average or expected value*

To estimate the impact of the AAZ treatment on participants, we calculate the Average Treatment on the Treated (ATT):

$$ATT = E(Y_1 - Y_0 | D = 1)$$

Then we measure the impact of the AAZ treatment on the untreated, we estimate the Average Treatment on the Untreated (ATU):

$$ATU = E(Y_1 - Y_0 | D = 0)$$

The parameters are not observable as they depend on counterfactual outcomes, hence the ATT is rewritten as:

$$ATT = E(Y_1 | D = 1) - E(Y_0 | D = 1)$$

Where:

$E(Y_0 | D = 1)$ is the average outcome that the AAZ participants would have had in the absence of the treatment and the term $E(Y_0 | D = 0)$ is for AAZ non-participants. Therefore, the average impact of AAZ treatment on smallholder agricultural commercialisation is estimated as:

$$\Delta = E(Y_1|D = 1 - E(Y_0|D = 0)$$

$$\Delta = E(Y_1|D = 1) - E(Y_0|D = 1) + E(Y_0|D = 1) - E(Y_0|D = 0)$$

$$\Delta = ATT + E(Y_0|D = 1) - E(Y_0|D = 0)$$

$$\Delta = ATT + SB$$

Where:

The second term, SB, is the selection bias which is the difference between participants and non-participants. The ATT can be calculated using the difference between the mean observed outcomes for treated and untreated cases if this term is equal to zero:

$$\widehat{\boldsymbol{ATT}} = \boldsymbol{E(Y|D = 1) - E(Y|D = 0}$$

CHAPTER FOUR-RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the characteristics of smallholder farmers in the Amatheon Agri Zambia out-grower scheme. The farmers are characterised as participants and non-participants. Participation in the AAZ out-grower programme means that a farmer received advice or training on any agricultural topic from AAZ, sold or bought grain to or from AAZ, received an input loan, or participated in either of the three treatment arms of AAZ. The households that received agricultural advice or training from AAZ are classified under treatment arm one(T_1). These households received free training from Amatheon for at least one agricultural season between 2013/2014 on various topics such as crop cultivation, postharvest handling, Conservation Agriculture (CA), input use, farming as a business, and sustainable land management practices. Individuals who received input support from AAZ in at least one agricultural season between 2013/2014 and 2020/2021 are classified under treatment arm two(T_2). Similarly, households that sold grain to AAZ under its guaranteed off-take market of harvested crops in at least one season between 2013/2014 and 2020/2021 are classified under treatment arm three(T_3). The general treatment(T_4), represents households that participated in any of the three treatment arms (T_1), (T_2) and(T_3), The comparison group (C) refers to households that did not participate in any of the three treatment arms from the beginning of AAZ in 2013/2014 until the time when AAZ restructured its out grower scheme in 2019/2020 to focus more on cash crops such as quinoa and chilli. Agricultural commercialisation entails market participation, and in this study, we measured commercialisation using the Household Commercialisation Index by developing proxies of maize, soya beans, and overall crop commercialisation indices

This chapter further uses descriptive statistics to discuss the shocks or disruptions that may have affected smallholder farmers' level of commercialisation since the AAZ intervention began in Mumbwa and Chibombo districts. In addition, the chapter discusses the econometric results. We discuss the determinants of agricultural commercialisation among smallholder farmers in the AAZ scheme using the Fractional logit regression model. We measure the impact of AAZ support on smallholder farmers by using the PSM estimates.

4.2. Treatments by Survey wave

Figures 3 and figure 4 below show the treatments at both survey periods for participating and non-participating households. The treatment arms are; the household received training or agricultural advice from AAZ (T_1), the household received input/seed bank loan from AAZ (T_2), the household sold any grain to AAZ(T_3), and if the household participated in either of the three treatment arms (T_4).

Training

At baseline, 58% of households received training or agricultural advice from Amatheon on different agricultural topics including crop postharvest handling, crop rotation, and conservation agriculture, farming as a business, marketing, and many others. The number of smallholder farmers that received training from AAZ increased to 68% at follow-up. Non-participants accounted for 43% of smallholder farmers that did not partake in the training offered by AAZ at the baseline while 33% did not take part in training at the end-line.

Input Loan

Results from Figure 6 above show that more households did not receive an input or seed bank loan from AAZ at baseline representing 67% of non-participant households while 54% did not receive the loan at the end-line either. Results further reveal that there was an increase in the number of participants who received an input loan from AAZ from 33% at baseline to 46% at the end-line.

Grain Sales to AAZ

The analysis revealed that 77% of households did not sell any grains to AAZ at baseline and this number decreased at the follow-up study to 68% while only 33% sold grain to AAZ at end-line compared to 23% at baseline. AAZ provided a guaranteed off-take market between 2013/14 and 2020/2021 by establishing trading depots in Mumbwa district where smallholder farmers had ease of access to the market for their outputs.

More non-participants were not involved in either of the treatment arms of AAZ at baseline representing 74% of the sample while 63% did not participate in either treatment at the end-line survey. During the end-line survey, at least 37% of participating households took part in either treatment arm while only 26% participated in either treatment at baseline.

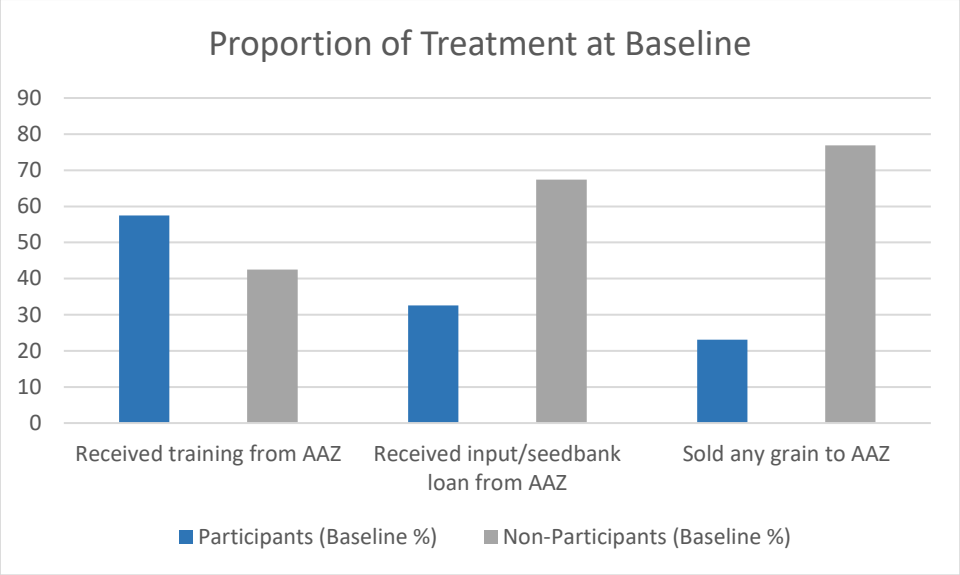

Figure 3: Proportion of Treatment at Baseline
Source: Author's compilation

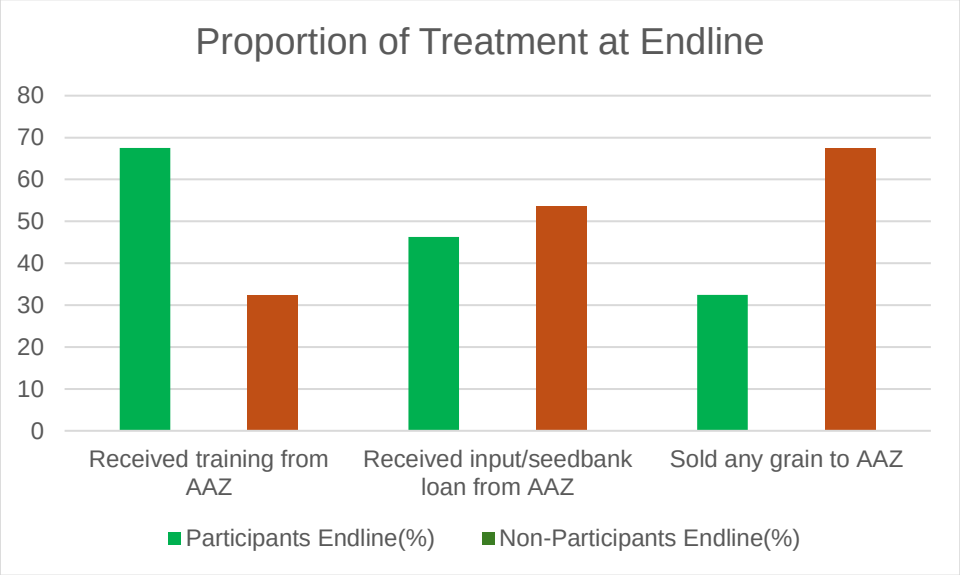

Figure 4: Proportion of Treatment at Endline
Source: Author's compilation

4.3 Household Socioeconomic Characteristics

Household socioeconomic characteristics are likely to influence the extent of agricultural commercialisation. To better understand the farm and household characteristics between AAZ participants and non-participants, the t-test was used to test for systematic differences in continuous variables between the two groups while a chi-square test was used for categorical variables as shown in Table 5 below.

Results show that there were no significant differences in the age of the household head between AAZ participants and non-participants, and the mean age was 45 for non-participants and 46 for participants with the minimum and maximum ages for household heads being 17 and 93 respectively. The age of household heads was categorised into three groups representing youths, middle-aged, and old-aged household heads, and found that both participant and non-participant household heads were middle-aged. Zambia has a relatively young population and most input support programmes are accessed through youth groups in this case, the majority of participants fall into both the youth and middle-aged groups (SAIRLA Research Briefing, 2019). There are fewer senior persons in the sample, which is in line with Alene et al., (2008) claim that market participation declines with age since older people have a tendency to be risk-averse and are less willing to accept new technology (Alene *et al.*, 2008).

There were significant differences in the education level of household heads and the maximum level of education attained for any household member between participants and non-participants. The mean years of education for household head participants in the AAZ out grower scheme was 8.05 while that of non-participants was 7.33. The mean years of education attained by any household member was 10.08 for participants and 9.35 for non-participants. Education attained was further divided into four categories: primary, junior and senior secondary, and tertiary education following the education system in Zambia. The average education level of the household heads in the study was junior secondary with a few attaining college or university education. Treated household heads have attained higher levels of education in all categories except the primary level where the majority are non-participants.

Ownership of agricultural assets such as oxen and a tractor had no significant difference between the treatment and control groups. However, there was a significant difference between the two groups in the household wealth index for those who owned either a car or a motorbike, AAZ participants had a higher wealth index of 0.3 and non-participants had a wealth index of 0.015. Studies show that households that own a motorbike or a car are more likely to participate in marketing as they find it easier to travel longer distances and relatively wealthier than those that do not (Makhura, 2001; Bwalya, 2013).

Results show that most participants have a closer relationship with the AAZ farmer coordinators than non-participants and tend to show significant differences in the AAZ treatment arms. Results reveal that 39.1% of AAZ participants are related to the farmer coordinator and 23.33% are not. The relationship of the household head or spouse to the farmer

coordinator might affect programme participation, for example, accessing input loans, receiving agricultural training or advice from the FC or selling grain to Amatheon.

Having access to the AAZ treatment arms might have also contributed to significant differences in the land access per capita, landholding size and the per capita farm size among programme participants. The average landholding size for AAZ participants was 6.32 Ha while that of non-participants was 4.99 Ha. Having a larger landholding size implies that the farmer is more likely to increase the total area allocated to a crop, for example, AAZ participants have a higher total cultivated land per crop of 4.94 Ha compared to non-participants with 3.83 Ha. Martey et al. (2012) found that a larger landholding size encourages the production of a market surplus.

The quantity harvested of maize shows a significant difference between participants and non-participants with participants having an average yield of 2210.22 Kg while non-participants have an average maize yield of 1978.69 Kg. It is interesting to note that there are no significant differences between participants and non-participants in the quantity harvested of soya beans, another crop that Amatheon gave out input loans.

The mean household size is 9 for participants and 8 for non-participants and the difference is significant. Mohammed et al., (2016); Tijani, (2018) found that large family sizes may guarantee a sufficient supply of household labour for crop production which could enhance market participation.

In addition, there are significant differences between participants and non-participants in terms of female-headedness as 13.4% and 18.6% are participants and non-participants respectively. There are more male-headed households in the study showing that men have a larger possibility of participating in markets attributable to their social networks than their female counterparts and make most of the decisions regarding the quantity of produce to sell (Gebreselassie and Ludi, 2008; Amfo *et al.*, 2022).

Results show that 86.0% and 79.6% of participant and of non-participant household heads are married and the difference between the two groups is significant. Scholars have argued that married household heads tend to be more organised and are likely to participate in markets because of the joint decision-making choices with their spouses (Tijani, 2018; Amfo *et al.*, 2022).

Group membership shows that there are significant differences between AAZ participants and non-participants as 53.0% of participants and 31.9% of non-participants either belonged to a

cooperative or a farmer group. Farmer groups are very important because they are a formation where farmers exchange information on buying and selling their produce and have access to loans. There were no significant differences in terms of loans accessed elsewhere apart from Amatheon for both participants and non-participants.

Agricultural production could be impeded by the occurrence of shocks or disruptions (Béné, 2020). Households were asked whether they experienced a shock or not. Results show that 87.8% of participant and 84.8% of non-participant households experienced a shock and some households had severe shocks. However, there were no significant differences between AAZ participants and non-participants.

Table 5: Mean Differences between AAZ Participants and Non-Participants

	Non-participant sample(N=227)	Participant sample (N=352)	
Variables	**Mean1**	**Mean2**	**Mean Difference**
Education level of household heads	7.334	8.054	-0.720***
Household size	8.093	9.378	-1.285***
Female-headed household Dummy=1	0.186	0.134	0.053**
Dummy=1 if household is married	0.796	0.86	-0.064***
Age of Household Head	45.389	46.727	-1.338
Max education of any household member, years	9.345	10.077	-0.732***
Agricultural index (pca), incl. tractor/oxen	-0.181	0.493	-0.674***
Agricultural index (pca), w/o tractor/oxen	-0.154	0.413	-0.566***
Agricultural index, only tractor/oxen/plough (pca)	-0.082	0.237	-0.319***
HH wealth index (pca), incl. motorbike/cars	-0.096	0.29	-0.385***
HH wealth index (pca), w/o motorbike/cars	-0.079	0.29	-0.369***
Maize yield Kg/ha planted	1978.69	2210.222	-231.531**
Soya yield Kg/ha planted	1057.445	1073.786	-16.342
Received training/advice from AAZ (T1)	0.468	1.00	-0.532***
Acquired input or loan (T2)	0.083	1.00	-0.917***
Sold grain to AAZ (T3)	0.185	0.438	-0.253***
Total crop cultivated ha	3.825	4.936	-1.111***
Land access, Ha	5.242	6.569	-1.327***
Size of land-holdings in Ha	4.989	6.324	-1.335***
Per capita farm-size, Ha	0.675	0.755	-0.080**
Dummy=1 if household irrigated	0.006	0.014	-0.008
Dummy=1 if household accessed a loan elsewhere away from AAZ	0.224	0.193	0.031
Dummy=1 if Household experienced a shock	0.848	0.878	-0.03
Chief related to Hhhead or spouse	0.096	0.117	-0.021
Headman related to Hhhead or spouse	0.461	0.469	-0.007
AAZ FC related to Hhhead or spouse	0.233	0.391	-0.158***
Group Membership	0.319	0.53	-0.211***
Distance to Lusaka town (km)	131.888	129.081	2.807
Distance to Mumbwa town (km)	50.63	50.502	0.128
Distance to Chibombo town (km)	85.408	84.741	0.667
Distance to Amatheon depot (km)	44.419	45.817	-1.398

Note: ***Significant at 1 per cent; **Significant at the 5 per cent level *Significant at the 10 per cent level
Source: Author's own compilation

4.4 Level of Agricultural Commercialisation among Smallholder Farmers in the Amatheon Out-grower Scheme

The minimum and maximum commercialisation levels for all crops were 0 and 1, respectively. The average HCI for maize is 0.44, soya beans 0.90 and overall crop commercialisation is 0.64 implying that soya beans are more commercialised. The mean farm gate price for maize and soya beans is 1.17 per kg and ZMW 3.02 per kg respectively as shown in Table 6.

Table 6: Mean Household Commercialisation Indices

Variable	Obs	Mean	Std. dev.	Min	Max
Maize Commercialisation	522	0.444	0.330	0.000	1.000
Soya Beans Commercialisation	427	0.899	0.154	0.000	1.000
Overall Crop Commercialisation	532	0.641	0.247	0.000	1.000
Maize price per kg(farm gate, ZMW)	378	1.166	0.405	0.236	5.148
Soya beans price per kg(farm gate, ZMW)	419	3.023	1.090	0.288	7.740

Source: Author's compilation

Before categorising smallholder farmers based on their level of commercialisation, the study analysed changes in commercialisation between out grower scheme participants and non-participants over two research waves. This is shown in Table 7.

Results show a generally significant increase in commercialisation between the treatment and control groups at both study rounds. Smallholder farmers in both groups increased their maize sales from 54.3% to 67.5% for treated households and 41.5% to 63.5% for the control households. Further analysis revealed that most soya beans are farmed primarily for commercial purposes since baseline commercialisation rates were greater for both participants and non-participants. Soya beans sales reduced at follow-up from 90.6% at baseline to 75.7% for participating households while for non-participating households, the sales decreased from 89.9% at baseline to 72.7% at follow-up and the difference was statistically significant. Two factors would have caused this decline in soya beans sales, the first one is that AAZ restructured its out-grower scheme to focus on more high-value crops like quinoa and bought more grains during its initial phase. The second factor is that crop yields decreased as shown in Table 7 below.

In addition to soya beans and maize, other crops such as cowpeas, groundnuts, sunflower and vegetables and fruits are grown in both districts and were used to calculate the overall crop

commercialisation index. The proportion of farmers in both the treated and control groups increased in both study periods.

Table 7: Mean differences in Agricultural Commercialisation Levels at Baseline and End line

Crop commercialisation	**Participants**			**Non-Participants**		
	***Household Commercialisation Index (HCI)**					
	Baseline	Follow-up	Difference	Baseline	Follow-up	Difference
Maize	0.543	0.675	0.132***	0.415	0.635	0.22***
Soya beans	0.906	0.757	-0.149***	0.899	0.733	-0.166***
Crop commercialisation	0.696	0.788	0.092***	0.625	0.76	0.135***
Maize yield, Kg/Ha planted	2699.47	1808.97	-890.5***	2149.98	1788.16	-361.82***
Soya beans yield, Kg/Ha planted	1638.997	1524.68	-114.32	628.77	559.87	-68.90

***Significant at 1 per cent; **Significant at the 5 per cent level *Significant at the 10 per cent level
Source: Author's compilation

Commercialisation levels were categorised into three categories: low, medium and high commercialisation. The proportion of both the treated and control households sold over 75% of soya beans with 79.17% of participants and 77.78% falling into this category. For the staple crop maize, most farmers are medium commercialised with 53.69% and 45.37% of treated and control households selling between 30%-75% of their grains. This is attributed to the availability of buyers including AAZ that set up trading depots to purchase maize and soya beans from smallholder farmers to integrate them into the rural value chains by acquiring grains through higher trading volumes. The proportion of farmers sold over 75% of cowpeas, groundnuts sunflower as well as fruits and vegetables indicating high commercialisation of the overall crops.

Table 8: Level of Agricultural Commercialisation

	Participants			**Non-Participants**		
	Maize	Soya beans	Overall Crop Commercialisation	Maize	Soya Beans	Overall Crop Commercialisation
Low Commercialisation	39	10	10	181	24	61
Medium Commercialisation	160	45	143	299	100	336
High Commercialisation	99	209	189	179	434	368

Source: Author's compilation

It is worth noting that the proportion of farmers selling below 30% is quite high for maize among participants and non-participants with 27.47% and 13.09% respectively. This is because

farmers may opt not to sell much and keep the maize until there is high demand and the price is increased.

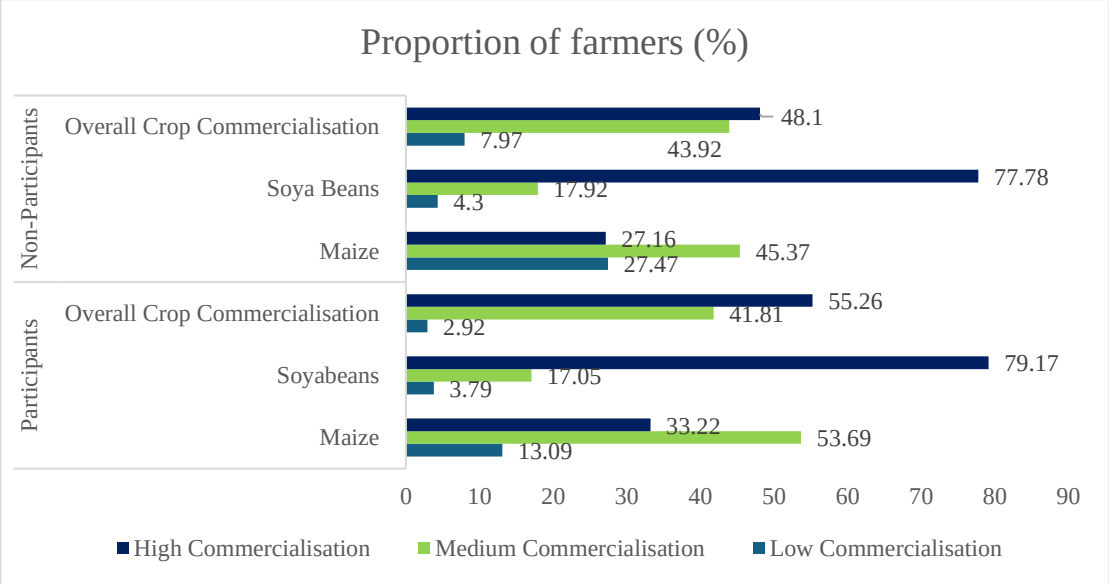

Figure5: Proportion of farmers according to commercialisation levels
Source: Author's compilation

4.5. Shocks or Disruptions affecting Agricultural commercialisation

Agricultural shocks can hinder smallholder agricultural commercialisation (Ngenoh *et al.*, 2018). Before conducting econometric analysis, the study used descriptive analysis to evaluate the various shocks households might have experienced. Table 9 shows the proportion of households that experienced a shock in the past five years before the end-line survey. Results show that more households experienced a shock at the end line than at the baseline of the study period.

Table 9: Proportion of Households that experienced a shock

Dummy if household experienced a shock in the past 5 years	Survey wave		Total
	Baseline	End-line	
N0=0	162	10	172
Yes=1	428	580	1,008
Total	590	590	1,181

Source: Author's compilation

Figure 5 below shows the most severe shocks that a household experienced, with the frequency of occurrence determining the severity of the shocks. These shocks are interconnected in some way or the other. For example, heavy rainfall or flooding can damage crops, livestock and infrastructure, making it difficult for farmers to produce and transport their products to market (Mera, 2018). Similarly, a dry spell or severe drought can lead to crop failure, devastatingly affecting smallholder household incomes, productivity and livelihoods. This, in turn, affects both input and output agricultural prices. When a market is affected by a flood, it reduces the price gap during the commercialisation period, ultimately affecting output prices which can lead to crop failure. Crop failure leads to strong price increases in agricultural price inputs, which many smallholder farmers cannot withstand, thus reducing crop productivity. When less has been harvested, it is very difficult for smallholders to sell the little produce as output prices are increased due to low supply, consequently impeding the intensity of market participation (Ngenoh *et al.*, 2018).

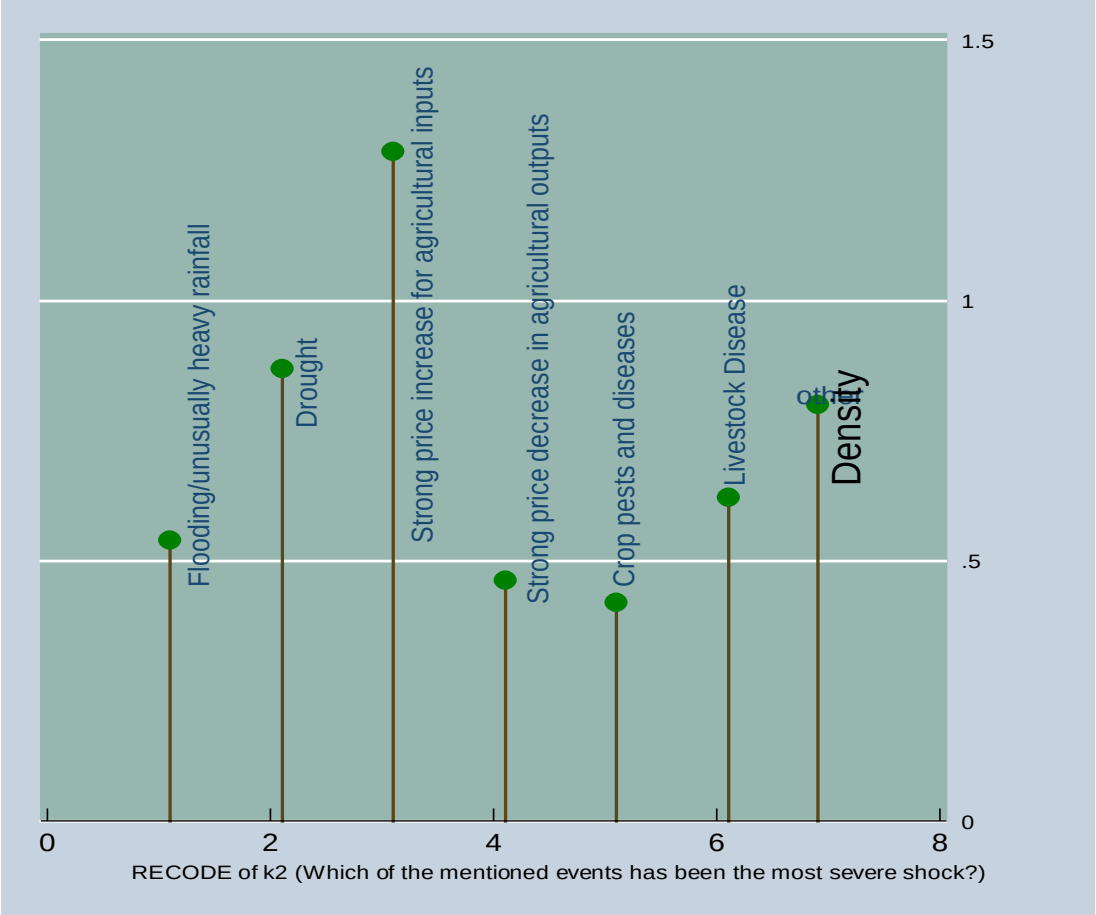

Figure 5: Severe Shocks Faced by Households
Source: Author's compilation

More severe shocks may require more drastic coping strategies, and households may not have the resources or capacity to implement these strategies. Households with more resources are likely to have more options for coping with shocks. For example, they may be able to purchase insurance, borrow money, or sell assets. Households with fewer resources may have to rely on less effective coping strategies, such as reducing food consumption or selling livestock. Households that are more vulnerable to shocks may be less able to cope with them. This is because they may have fewer resources, less access to formal support systems, and less experience coping with shocks. Some households may be more risk-averse than others. Risk-averse households may be less likely to take on debt or invest in new coping strategies, even if these strategies could help them mitigate the impact of a shock (Ngenoh *et al.*, 2018). Figure 6 shows that the sampled households had little or nothing to cope with the severe shocks and a few managed to use their savings, sold livestock or reduced production inputs to mitigate the effects of these shocks. Appendix C shows the frequency of the coping strategies of the sampled households.

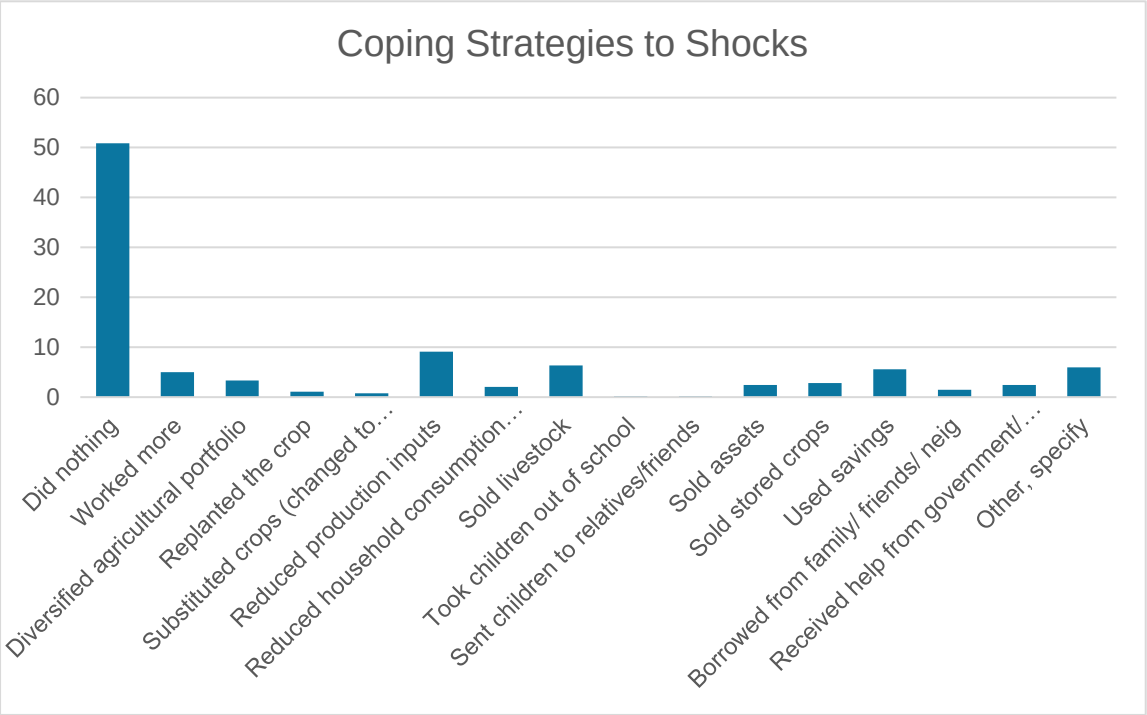

Figure 6: Coping Strategies to Shocks
Source: Author's compilation

4.6 Econometric Results

4.6.1. Determinants of Agricultural Commercialisation in the AAZ Out grower Scheme

Fractional regression fits a fractional response model for a dependent variable that is greater than or equal to 0 and less than or equal to 1 (Harald Oberhofer and Michael Pfaffermayr, 2012). It uses a probit, logit, or heteroskedastic probit model for the conditional mean. These models are often used for outcomes such as rates, proportions, and fractional data (Meaney and Moineddin, 2014; Gallani, Krishnan and Wooldridge, 2015).

4.6.2. Determinants of maize commercialisation

Fractional logistic regression results for determinants of maize commercialisation are shown in Table 10 below. Based on the Wald chi-squared test, it has been found that the predictor variables have a significant joint impact on the variations in maize commercialisation. Specifically, they contribute to about 4.49% of the variations in maize commercialisation. This result is significant at a 5% level.

Results show that the age of the household head, ownership of a tractor or oxen, household wealth indicated by ownership of a motorcycle or car, absence of a motorcycle or car, maize yield, the average maize price per unit, farm size and distance to Lusaka significantly determine maize commercialisation in the Amatheon Out grower scheme.

In the AAZ out grower scheme, low maize sales are significantly and negatively associated with the age of the household head. The likelihood of engaging in the maize market falls by 6.65%, *ceteris paribus*, as the age of the household head increases. The implication is that older farmers would rather grow maize for domestic use rather than sell it as younger farmers would. This finding is in line with that of Abu et al., (2014) who discovered that the household head's age had a negative impact on commercialisation. Older farmers may be more concerned about their ability to access food than younger farmers, therefore they might be less willing to take the risk of selling their staple crop relative to younger farmers. A study by Randela et al., (2008) shows that young farmers are more receptive to change and better understand the benefits of agricultural commercialisation. Despite Martey et al., (2012) findings, our results contradict them. The authors found a positive relationship between the age of the household head and maize commercialisation. The age of the household head is used as a proxy for farming experience. Compared to younger household heads, older household heads have more contacts, which gives them an advantage when searching for trading partners.

Ownership of agricultural assets such as a tractor, oxen, motorcycle, or car significantly and positively. An increase in the ownership of a tractor or oxen increases the probability of participation in the marketing of maize by 0.86% while an increase in the ownership of a motorcycle or car increases the commercialisation of maize by 12.49% holding all other factors constant. Ownership of livestock such as oxen can stimulate maize sales as these are used to transport agricultural produce to the local market centres or traders' locations (Makhura, 2001; Bwalya, 2013). Households that own pick-up trucks have shown higher market participation levels as ownership of transport equipment such as a car or motorcycle significantly reduces transportation costs and barriers in the market (Key, Sadoulet and Janvry, 2000). On the contrary, results further show that households in the AAZ scheme that did not own either a motorcycle or a car had a significant negative influence on maize commercialisation. All other factors held constant, owning a motorcycle or a car decreases the probability of selling maize by 1.32%, which is consistent with other authors who argue that owning such transport equipment reduces transaction costs and increases market participation (Key, Sadoulet and Janvry, 2000; Makhura, 2001; Bwalya, 2013; Hailua *et al.*, 2015).

Results further reveal that the maize yield positively and significantly influenced maize commercialisation. As expected, an increase in the average yield of maize by one kilogram per hectare increases the probability of participating in the maize market by 85.89%. This discovery aligns with the research of Geoffrey et al., (2013) and Hailua et al., (2015), indicating that an increase in crop yield greatly contributes to participating in the crop market. Households with higher volumes of harvested crops are more likely to sell their produce compared to those with lower volumes of yield and this reduces transaction costs per unit of good traded (Kirsten *et al.*, 2009; Tijani, 2018).

In addition, results show that the maize farm gate price positively and significantly contributes to maize commercialisation in the AAZ out grower scheme. The unit price of maize influences households to supply more maize to the market. A one Kwacha increase in the price of maize leads to a 96.14% increase in the amount of maize sold to the market. This finding is consistent with (Olwande and Mathenge, 2011) who ascertained that output price is an incentive for households to supply more produce to the market thus confirming the economic theory of output-price incentive for market participation (Key, Sadoulet and Janvry, 2000).

Farm size is positive and significant implying an increase in the farm size contributes to a 53.5% probability of selling maize other factors held constant. This finding agrees with Amfo et al., (2022) who postulated that households with larger farm sizes are more likely to sell larger quantities of produce compared to those with smaller farm sizes as they obtain enough outputs to feed their families and sell the surplus to the market.

As expected, the distance to Lusaka is negative and significant in the Fractional regression output. This means that a one-kilometre increase in the distance to the capital city reduces the probability of participating in the maize market by 61.68%, holding other factors constant. This can be attributed to higher transaction costs that the farmer incurs as they take their maize to Lusaka since prices are charged per unit of produce. Smallholder farmers in Mumbwa and Chibombo would rather find alternative buyers of maize in the local districts than sell it to Lusaka. The presence of alternative markets in the districts increases the efficiency of the marketing system and reduces the monopolistic tendencies of maize buyers (Barrett, 2008; Kirsten *et al.*, 2009). Our findings are consistent with other findings where the distance to the capital was negative and significant in market participation and that shorter distances reduce the magnitude of transaction costs by reducing the amount of time and money spent searching for buyers and price information (Kirsten *et al.*, 2009; Amfo *et al.*, 2022).

Table 10: Determinants of Maize Commercialisation

Variables	Maize Commercialisation Coefficient	Marginal Effects	P>Z
Female-Headed household, 1=Yes	0.0465	.0013858	0.623
	(0.0951)		
Household head Age, years	-0.00662***	-.0664733	0.009
	(0.00254)		
Household Size	0.0117	.0221589	0.275
	(0.0108)		
Heads Education, years	-0.00504	-.0086269	0.666
	(0.0117)		
Received training/advice from AAZ (T_1)	-0.0417	-.0059538	0.598
	(0.0788)		
Acquired input loan from AAZ (T_2)	0.0538	.0046416	0.484
	(0.0773)		
Sold grain to (T_3) AAZ	0.0809	.0052837	0.323
	(0.0826)		
Group membership (Dummy=1)	-0.0358	-.0034361	0.600
	(0.0680)		
Dummy=1 if hh accessed loan from sources other than AAZ	0.117	.0058982	0.130
	(0.0793)		
Agricultural asset index_pca (including oxen/tractor)	0.114***	.0085712	0.000
	(0.0260)		
HH wealth index_pca1(incl. motorbike/car)	0.257***	.0124927	0.003
	(0.0925)		
HH wealth index_pca2(w/o motorbike/car)	-0.234**	-.0132389	0.016
	(0.0959)		
Maize Yield Kg/Ha planted	0.000168***	.0858935	0.000
	(2.57e-05)		
Maize price per kg (farm gate price, ZMW)	0.258***	.0961358	0.000
	(0.0490)		
Per capita farm size, Ha	0.328***	.053514	0.000
	(0.0709)		
Event Shocks Index (PCA)	-0.0221	-.0017994	0.910
	(0.0319)		
Distance to Lusaka town (Km)	-0.0217*	-.6168328	0.094
	(0.0130)		
Distance to Mumbwa town (Km)	0.0151	.1674431	0.168
	(0.0110)		
Distance to Chibombo town (Km)	0.00662	.121743	0.438
	(0.00854)		
Distance to Amatheon depot (Km)	-0.0217	-.217591	0.150
	(0.0151)		
Constant	2.097		
	(1.588)		
Observations	700		
Wald Chi2(20)	281.000		
Prob > Chi2	0.0000		
Pseudo R2	0.0449		
Log Pseudo Likelihood	-439.50141		

*** p<0.01, ** p<0.05, * p<0.1 Robust standard errors in parentheses
Source: Author's compilation

4.6.3. Determinants of Soya Beans Commercialisation

Results from the fractional regression on soya beans commercialisation in Table 11 show that the household size, ownership of tractor or oxen, soya beans yield, farm gate price of soya beans, and treatment arm one which implies that a household received agricultural training or advice from AAZ significantly influence soya beans commercialisation. The Wald chi-squared test shows that the predictor variables jointly and significantly explain the variation in the model. They contribute 6% in the variation of soya beans commercialisation at a 5% significance interval.

Household size significantly but negatively influences the market participation of soya beans in the AAZ out grower scheme. The implication is that an increase in household size leads to a 7.64% decrease in the probability of soya beans commercialisation. Studies have shown that household size is posited as an indicator of the amount of labour available for production activities on the farm and also determines the consumption level of the household (Alene *et al.*, 2008; Byron *et al.*, 2014). Hence, the larger the household size, the more efficient the household is in agricultural production. However, our results contradict the findings of (Dube and Guveya, 2016) but are consistent with the findings of (Tadele *et al.*, 2017) who found that household size negatively influenced wheat commercialisation.

According to the results, treatment arm one, access to agricultural training or advice, has a significant impact but has a negative impact on soya beans market participation. Participation in the AAZ out grower scheme required households to participate in at least one of the treatment arms; training, selling grain to AAZ, or acquiring an input loan. Attending AAZ training does not necessarily indicate that a household participated in marketing the crop. Some households may have received training but did not obtain soya bean input loans or sell any of the crops. The training's broad scope, covering lime application, fertiliser handling, and post-harvest practices, might lack the necessary specificity required for optimising soya bean commercialisation. Soya beans, like many crops, have specific requirements and challenges concerning cultivation, pest management, market demand, and pricing dynamics (Abah, 2020). The generic nature of the agricultural training might not sufficiently address the intricacies of successful soya bean commercialisation, thereby failing to equip farmers with the precise knowledge needed to excel in marketing this particular crop. The training program's emphasis on technical aspects of farming and business might overlook or underemphasise the critical component of market linkages. Effective commercialisation often requires insights into market

trends, access to market information, and strategies for selling produce, elements that might not be adequately covered in the training provided. Some households might have received training but did not fully engage in marketing soya beans. This disconnect between the information provided in the training and its practical implementation in soya bean commercialization might lead to an apparent negative impact on market participation despite having received the agricultural advice.

This finding disagrees with Alene et al., (2008); Byron et al., (2014) who postulated that access to agricultural extension services can improve market participation and increase the marketable surplus of soya beans by offering technical assistance and agronomical information on improved soya bean seed varieties. The average yield of soya beans significantly and positively determines soya bean commercialisation in the AAZ out grower scheme. Fractional regression results indicate the marginal effect of soya bean yield is positive indicating that a one-kilogram increase per hectare planted of soya beans increases the probability of market participation of the pulse by 5.89% all other factors held constant. A household with higher volumes of soya beans harvested has a higher marketable surplus of soya beans. This finding is consistent with the findings of (Byron et al., (2014 and Stephen et al., (2017).

The farm gate price of soya beans per kilogram significantly and positively influences soya beans commercialisation. This implies that a one Kwacha increase in the farm gate price of soya beans leads to a 5.6% probability of participating in the marketing of soya beans. Higher prices are an incentive for households to participate in crop marketing (Randela, Alemu and Groenewald, 2008). This aligns with the research conducted by Stephen et al., (2017), which suggests that farmers make logical choices and value higher market prices, resulting in a slight rise in commercialization.

Experiencing a shock significantly and negatively influences the commercialisation of soya beans. For every household that experiences a shock, there is a 6.5% decrease in the probability that it will participate in the marketing of soya beans. Weather shocks such as floods and droughts could negatively affect crop production and have an impact on price differentials especially on transportation costs (Salazar, Ayalew and Fisker, 2019). Transaction costs may increase during a flood due to damaged feeder roads in most rural areas hence limiting market access for soya beans. This finding agrees with that of (Salazar, Ayalew and Fisker, 2019) who found that floods affect price dispersion which is a result of transport costs and road operability thus affecting commercialisation.

Table 11: Determinants of soya beans commercialisation

Variable	Soya beans commercialisation Coefficient	Marginal Effects	P>Z
Female-headed Households 1=yes	-0.183	-0.0037119	0.359
	(-0.184)		
Household head age, years	-0.00226	-0.0136642	0.627
	(-0.00462)		
Household size	-0.0637***	-0.0763803	0.000
	(-0.0144)		
Household head education, years	-0.0216	-0.021927	0.236
	(-0.018)		
Received training/advice from AAZ($\boldsymbol{T_1}$)	-0.247**	-0.0214366	0.048
	(-0.12)		
Acquired input loan from AAZ ($\boldsymbol{T_2}$)	0.0874	0.0042346	0.475
	(-0.125)		
Sold grain to AAZ ($\boldsymbol{T_3}$)	0.0395	0.0014151	0.782
	(-0.144)		
Group membership	0.00708	0.0003981	0.948
	(-0.11)		
Loan access from other sources other than AAZ, Dummy=1	0.207	0.0053654	0.095
	(-0.137)		
Agricultural asset index_pca (including oxen/tractor)	0.0714*	0.0020497	0.015
	(-0.0387)		
HH wealth index_pca1(incl. motorbike/car)	0.136	0.0032268	0.286
	(-0.134)		
HH wealth index_pca2(w/o motorbike/car)	-0.138	-0.0039969	0.332
	(-0.135)		
Soya beans yield Kg/Ha planted	0.000542***	0.0588909	0.000
	(-7.65E-05)		
Soya beans price per kg (farm gate price, ZMW)	0.122***	0.0560216	0.000
	(-0.0373)		
Per capita farm size, Ha	-0.061	-0.0056091	0.521
	(-0.0939)		
Events shocks_pca_index	-.0280797*	-.0649	0.464
	(-0.131)		
Distance to Lusaka town (Km)	0.00886	0.1437756	0.676
	(-0.0212)		
Distance to Mumbwa town (Km)	0.00385	0.0253524	0.838
	(-0.0188)		
Distance to Chibombo town (Km)	-0.00805	-0.0839968	0.503
	(-0.012)		
Distance to Amatheon depot (Km)	-0.00399	-0.025307	0.879
	(-0.0262)		
Constant	1.649		
	(-2.827)		
Observations	725		
Wald chi2(20)	146.82		
Prob > chi2	0.0000		
Pseudo R2	0.0600		
Log pseudo-likelihood	-303.60342		

*** p<0.01, ** p<0.05, * p<0.1 Robust standard errors in parentheses

Source: Author's compilation

4.6.4. Determinants of Crop Commercialisation

Results of the determinants of crop commercialisation from the fractional regression are shown in Table 12 below. The Wald chi-square value of 183.97 is statistically significant at 1% indicating that the explanatory variables jointly explain the probability of participating in crop commercialisation. Crop commercialisation is significantly determined by the age of the household head, household size, and level of education of the household head, households selling grain to AAZ, loan access from sources other than AAZ, ownership of a tractor or oxen and the total land cultivated.

The results show that the age of the household head significantly and negatively influences crop commercialisation. An increase in the age of the household head by one year decreases the probability of commercialisation of crops in the AAZ out grower scheme by 6.98%, all factors held constant. This posits that younger farmers are more likely to participate in crop marketing than older farmers as older farmers might want to store more crops for home consumption. This finding is consistent with Chilimboyi, (2021) and Madududu et al., (2022) who found that the age of the household head significantly and negatively affected crop commercialisation.

Household size significantly and positively influences crop commercialisation. An additional household member increases the probability of crop commercialisation by 5.02% *ceteris paribus*. This result is consistent with the findings of (Bekele & Alemu, 2015 and Dube & Guveya, 2016) who found that a larger household size is more likely to commercialise their crop surplus.

The household head's level of education significantly and positively influences crop commercialisation. An increase in the year of schooling of the head of a household increases the probability of participating in crop marketing by 3.29%, all factors held constant. The finding agrees with Tadele et al., (2017) who argued that the level of education of the household head increases wheat commercialisation in Ethiopia.

Treatment arm three, household having sold grain to AAZ significantly and positively determine crop commercialisation at 1% significance level. An increase in the amount of grain sold to AAZ increases the probability of commercialisation by 1.14%, all factors held constant. This result is attributed to the marketing component of the AAZ's portfolio of buying crops such as sunflower, cowpeas and groundnuts hence improving farmers' crop sales. Barrett,

(2008) posits that having access to a buyer enhances market participation and reduces transaction costs faced by smallholder farmers.

Loan accessed from sources other than AAZ is significant at 1% and positively influences crop commercialisation. An increase in the loan from other sources leads to a 0.91% increase in crop commercialisation holding other factors constant. Credit access has been found to ease smallholder farmers of financial constraints and help them participate in businesses of their choice (Falola *et al.*, 2017; Abah, 2020).

Ownership of a tractor or oxen is significant and positively influences crop commercialisation. A household that owns a tractor or oxen has the probability of increasing crop commercialisation by 0.186% holding other factors constant. The use of assets such as and tractors draught oxen in agricultural production enhances marketable surplus at the smallholder household level (Jaleta, Gebremedhin and Hoekstra, 2009). Our finding agrees with Hailua et al., (2015) who found that ownership of oxen positively and significantly stimulates crop commercialisation.

The total cultivated land is significant at 1% and positively influences crop commercialisation in the AAZ out grower scheme. A one hectare increase in the total cultivated land leads to a 4.06% probability of a household commercialising their crop. The total cultivated land has an effect on the crop harvested and thus affects the quantity of crop supplied to the market. Thus finding is in line with the study by Hailua et al., (2015) and Gebreselassie & Ludi, (2008) who found that the proportion of land allocated to a crop had a positive and significant impact on a household's level of market participation.

Table 12: Determinants of Crop Commercialisation

Variables	Crop Commercialisation Coefficient	Marginal effects	P>Z
Female-headed household, Dummy=1	-0.0502 -0.103	-0.0017078	0.63
Household head age, years	-0.00762*** -0.00289	-0.0698133	0.009
Household size	0.0311*** 0.0114	0.050217	0.005
Household head education, years	0.0224* -0.0129	0.0328795	0.08
Received training/advice from AAZ (T_1)	-0.0325 -0.0776	-0.0040304	0.676
Acquired input loan from AAZ (T_2)	0.0676 -0.0718	0.0044299	0.339
Sold grain to AAZ (T_3)	0.231*** 0.0857	0.0114058	0.005
Group membership	0.0208 -0.0667	0.0015763	0.754
Loan access from other sources other than AAZ	0.220*** 0.0754	0.0091302	0.002
Agricultural asset index_pca (including oxen/tractor)	0.0815*** 0.0244	0.001857	0.030
HH wealth index_pca1(incl. motorbike/car)	0.0978 -0.0867	0.0023429	0.285
HH wealth index_pca2(w/o motorbike/car)	-0.088 -0.0878	-0.0012827	0.298
Per capita farm size,Ha	0.0415 -0.0793	0.0055783	0.599
Events shocks (pca_index)	-.0379489 0.0911	-0.0379	0.114
Distance to Lusaka town (Km)	-0.00954 -0.0137	-0.2484406	0.485
Distance to Mumbwa town (Km)	0.00573 0.0121	0.0575537	0.637
Distance to Chibombo town (Km)	0.0019 0.00792	0.0321316	0.810
Distance to Amatheon depot (Km)	-0.0112 -0.0166	-0.0993583	0.4990
Total cultivated crop_ha	0.0550*** 0.012	0.0405511	0.0000
Constant	1.552 1.749		
Observations	971		
Wald chi2(19)	183.97		
Prob > chi2	0.0000		
Pseudo R2	0.0359		
Log pseudo likelihood	-565.71966		

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: Author's compilation

4.7 The Impact of AAZ on Smallholder Commercialisation Using Propensity Score Matching

To evaluate the impact of AAZ support on smallholder agricultural commercialisation in the out grower scheme, the study used a binary probit response to establish propensity scores for both the treated and control groups, considering the commercialisation indices of each crop in the household.

4.7.1. Impact of AAZ on Maize Commercialisation- PSM Estimates

The level of education of the household head, household size, group membership and the kinship ties to the AAZ farmer coordinator have significant and positive propensity scores. This implies that the selected covariates influenced the selection of farmers for the AAZ programme. Education plays a critical role in selecting programme participants, with household heads who attained a certain level of education being more likely to participate in the AAZ scheme than their counterparts. Larger households and those that belonged to a cooperative group or any trading group are also more likely to participate in the out grower scheme and hence receive the AAZ support. In addition, household heads or their spouses who are related to AAZ farmer coordinators are also more likely to receive any of the treatment arms of Amatheon as they have closer ties than their counterparts. Similar findings have been reported in studies such as (Bekele and Alemu, 2015; Herrmann, 2016) which demonstrated the positive association between education, group membership, and increased commercialisation of agricultural products. Results of the probit estimates for maize commercialisation are presented in Table 13.

Table 13: Probit Estimates of PSM for Maize Commercialisation

Variable	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Household head education, years	0.0548	0.0172	3.1800	0.0010	0.0211	0.0886
Household head age, years	0.0045	0.0039	1.1500	0.2520	-0.0032	0.0121
Household size	0.0681	0.0130	5.2200	0.0000	0.0425	0.0936
Group membership	0.3552	0.0976	3.6400	0.0000	0.1640	0.5465
Per capita farm size, Ha	0.1351	0.0923	1.4600	0.1430	-0.0458	0.3160
Kinship ties to the chief	0.0369	0.1633	0.2300	0.8210	-0.2832	0.3569
Kinship ties to the headman	-0.0133	0.1063	-0.1300	0.9000	-0.2216	0.1949
Kinship ties to the FC	0.4970	0.1100	4.5200	0.0000	0.2814	0.7127
Distance toAmatheon (Km)	-0.0018	0.0019	-0.9100	0.3610	-0.0055	0.0020
_cons	-2.0706	0.2907	-7.1200	0.0000	-2.6404	-1.5008
Number of observations	833					
LR chi2(9)	84.99					
Prob>chi2	0.0000					
Pseudo R2	0.0831					
Log likelihood	-468.95604					

Source: Author's compilation

Upon completion of propensity score estimation, comparable observations were matched to produce a subsample of respondents with comparable pre-treatment characteristics, with discrepancies in treatment being the only variable. The outcomes of this subsample are presented in Table 14.

Table 14: Subsample after estimating PSM on Maize Commercialisation

Treatment Assignment	Common support		Total
	Off support	On support	
Untreated	0	249	249
Treated	4	331	331
Total	4	580	580

Source: Author's compilation

A test was conducted to check if there were any biases left after matching the observed characteristics. Table 15 shows that for each covariate, there was a significant reduction in bias from the PSM estimation, both for the treated and control groups. The %bias for the kinship ties to the chief, headman, and AAZ farmer coordinator is less than 10%, indicating that the matching process is successful in balancing the covariates between the treated and control groups. This makes them more comparable, as seen in the means of the covariates for both

groups. A graphical representation of the balancing test for maize commercialisation covariates between the treated and control groups is available in Appendix 5.

Table 15: Balancing Test after Matching for Maize Commercialisation

	Mean			t-test		
Variable	**Treated**	**Control**	**%bias**	**t**	**p>t**	**V(T)/V(C)**
Household head education, years	8.1606	8.1002	2.1	0.24	0.813	0.89
Household head age, years	46.562	46.821	-2	-0.23	0.819	0.88
Household size	9.3574	9.5788	-5.7	-0.6	0.548	0.75*
Group membership	0.53012	0.52295	1.5	0.16	0.873	.
Per capita farm size, Ha	0.79739	0.8114	-2.6	-0.28	0.781	0.97
Kinship ties to chief	0.10843	0.10771	0.2	0.03	0.979	.
Kinship ties to headman	0.46988	0.47001	0	0	0.998	.
Kinship ties to FC	0.39759	0.36346	7.3	0.998	0.434	.
Distance to Amatheon (Km)	44.997	45.979	-3.9	-0.44	0.662	1.12

Source: Author's compilation

After reducing biases in the treatment and control groups for maize commercialisation and ensuring no differences in covariates, the study generated ATT estimates to determine the average outcomes in both groups. Table 16 shows that approximately 61.08% of individuals in the treated group have maize commercialisation, while the control group has 49.45%. The difference in maize commercialisation proportions between the two groups is approximately 11.64%, and the standard error associated with the difference is approximately 0.0228. The t-statistic for the difference is approximately 5.09, indicating that the difference is not random. The unmatched analysis suggests that there is a significant difference between the treated and control groups, with the treated group having a higher proportion of maize commercialisation. In summary, both the unmatched analysis and the ATT suggest significant differences in maize commercialisation between the treated and control groups, implying that receiving support from AAZ improves smallholder farmer's commercialisation of maize by 61.08% compared to those who do not receive support from AAZ.

Table 16: Impact of AAZ on Maize Commercialisation

Variable Sample	Treated	control	Difference	S. E	T-statistic
Maize Commercialisation Unmatched	.610835954	.494477953	.116358001	.022841644	5.09
ATT	.609555287	.553138436	.056416851	.023830962	2.37

Source: Authors' compilation

4.7.2 Impact of AAZ on Soya Beans Commercialisation-PSM Estimates

The covariates that were included in the probit estimation of PSM for soya beans are those that are likely to influence the selection to participate in the AAZ out grower scheme. The results in Table 17 show that kinship ties to the AAZ FC, household size and group membership positively and significantly influenced the selection to participate in the treatment arms of AAZ. This implies that household heads or their spouses who have close ties to the farmer coordinator are more likely to be selected for the AAZ programme than those with no ties. Household heads with larger family sizes are also more likely to receive support from AAZ than those with smaller household sizes. Belonging to a group or cooperative influences selection into the AAZ out grower scheme and receiving support.

Table 17: Probit Estimates of PSM for Soya beans Commercialisation

Variable	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Household head education, years	0.0365	0.0183	1.9900	0.0470	0.0005	0.0724
Household head age, years	0.0066	0.0043	1.5500	0.1210	-0.0017	0.0150
Household size	0.0701	0.0147	4.7600	0.0000	0.0412	0.0989
groupmembership	0.3593	0.1037	3.4600	0.0010	0.1560	0.5625
Per capita farm size, Ha	0.1877	0.0981	1.9100	0.0560	-0.0046	0.3799
Kinship ties to chief	0.1350	0.1772	0.7600	0.4460	-0.2123	0.4822
Kinship ties to headman	-0.0456	0.1136	-0.4000	0.6880	-0.2683	0.1770
Kinship ties to FC	0.6399	0.1171	5.4600	0.0000	0.4104	0.8694
Distance to Amatheon (Km)	-0.0029	0.0020	-1.4000	0.1600	-0.0069	0.0011
_cons	-2.0628	0.3141	-6.5700	0.0000	-2.6784	-1.4472
Number of obs	729.0000					
LR chi2(9)	83.0600					
Prob > chi2	0.0000					
Pseudo R2	0.0920					
Log Likelihood	-409.8004					

Source: Author's compilation

After estimating the propensity scores, comparable observations were matched to create a subset of respondents with similar pre-treatment characteristics, with differences in treatment only. The number of respondents in the treatment and control groups is now equal after the matching process, indicating that common support has been achieved. The Propensity Score

Matching (PSM) technique matched pairs from both groups based on their propensity scores, ensuring that they have similar means. The results of the matching process are presented in Table 18.

Table 18: Subsample of PSM estimates for soya beans commercialisation

Treatment Assignment	**Common Support**		**Total**
	Off Support	On Support	
Untreated	0	224	224
Treated	2	366	366
Total	2	590	590

Source: Author's compilation

A test was conducted to check if there were any biases left after matching the observed characteristics. Table 19 shows that for each covariate, there was a significant reduction in bias from the PSM estimation, both for the treated and control groups. The smaller percentage of biases indicates that the matching process was successful. Appendix 6 shows the balancing test graphically.

Table 19: Balancing Test after Matching for Soya Beans Commercialisation

	Mean			**t-test**		
Variable	**Treated**	**Control**	**%bias**	**t**	**p>t**	**V(T)/V(C)**
Household Head education, years	8.1162	7.8903	7.8	0.8300	0.4090	0.97
Household head age, years	46.8535	47.754	-7.2	-0.7500	0.4560	0.81
Household size	9.3885	9.5005	-3	-0.3000	0.7650	0.85
Group membership	0.5446	0.5454	-0.1	-0.0200	0.9880	.
Per capita farm size, Ha	0.8038	0.8303	-5	-0.4900	0.6270	0.85
Kinship ties to chief	0.1161	0.1198	-1.2	-0.1200	0.9030	.
Kinship ties to headman	0.4643	0.4739	-1.9	-0.2000	0.8390	.
Kinship ties to FC	0.4196	0.4017	3.9	0.3900	0.7000	.
Distance to Amatheon (Km)	45.6735	47.4030	-6.9	-0.7300	0.4640	1.12

Source: Author's compilation

ATT estimates were generated after reducing the biases in the treatment and control subsamples and balancing the covariates after determining there are no differences between the two groups in outcomes. The unmatched analysis suggests a small difference of 0.0019 in the means of soya beans commercialisation between the treated and control groups. The T-statistic of 0.11 indicates that this difference is not statistically significant at 5% significance level. The ATT analysis also indicates a difference of 0.0044 in the means of soya beans commercialisation

between the treated and control groups. The T-statistic of 0.22 suggests that this difference is not statistically significant at conventional 5% significance level. ATT shows that the differences in means for soya beans commercialisation are small, and the associated T-statistics indicate that these differences are not statistically significant. This further implies that both the treated and control groups experienced the same impact of AAZ on soya beans commercialisation. Hence, households that received support from AAZ commercialised soya beans by 83.0% and the effect was the same on non-participant households. Table 20 shows that both the ATT estimate and the difference between the two groups are positive, which indicates that the AAZ treatment has a positive impact on soya bean commercialisation.

Table 20: Impact of AAZ on Soya Beans Commercialisation

Variable Sample	Treated	Control	Difference	S.E.	T-stat
soya_commercial Unmatched	.830437895	.828534942	.001902953	.01696785	0.11
ATT	.83144724	.827072456	.004374783	.019505567	0.22

Source: Author's compilation

4.7.3. Impact of AAZ Support on Overall Crop Commercialisation

Household size, group membership and the household head's relationship with the farmer coordinator significantly and positively influence participation in the AAZ out grower scheme. A household head with a larger household size is more likely to be selected for the programme compared to one with a smaller household size. Along the same line, a household with a group membership to any social or cooperative group or is closely related to the AAZ farmer coordinator is also likely to receive support from an out grower scheme in the commercialisation of cowpeas, sunflower, groundnuts and fruits and vegetables, overall crop commercialisation in short. Results of the probit estimates for overall crop commercialisation are shown in Table 21.

Table 21: Probit Estimates of PSM for Overall Crop Commercialisation

Treatment	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Household head education, years	0.043517	0.015941	2.73	0.006	0.012273	0.074762
Household head age, years	0.004952	0.003678	1.35	0.178	-0.00226	0.012162
Household size	0.075814	0.01247	6.08	0.000	0.051373	0.100254
Group membership	0.395445	0.09087	4.35	0.000	0.217344	0.573547
Per capita farm size	0.155497	0.086758	1.79	0.073	-0.01455	0.325539
Kinship ties to chief	0.054008	0.151483	0.36	0.721	-0.24289	0.350908
Kinship ties to headman	-0.02739	0.09818	-0.28	0.780	-0.21982	0.165039
Kinship ties to FC	0.526181	0.102313	5.14	0.000	0.325651	0.726711
Distance to Amatheon (Km)	-0.00123	0.001788	-0.69	0.493	-0.00473	0.002277
_cons	-2.13351	0.272825	-7.82	0.000	-2.66824	-1.59878

Source: Author's compilation

Tables 22 and 23 show the overlap of the propensity score distributions between treatment and comparison groups. We considered the overlap to be satisfactory in its extent. We were able to attain balance in all quintiles between the treatment and comparison groups in our final propensity score definition. Appendix 7 displays a graphical illustration of the balancing test.

Table 22: Subsample of PSM estimates for Overall Crop commercialisation.

Treatment assignment	off support	On support	Total
Untreated	0	86	86
Treated	1	290	290
Total	1	376	376

Source: Author's compilation

Table 23: Balancing Test after Matching for Overall Crop Commercialisation

Variable	Mean		t-test			V(T)/V(C)
	Treated	Control	%bias	t	t p>t	
Household head education, years	8.0862.7	7.9865	3.4	0.41	0.680	0.97
Household head age, years	47.47	47.3160	-1.9	-0.23	0.818	0.88
Household size	9.6	9.7850	-4.8	-0.54	0.590	0.75*
Group membership	0.54138	0.5329	1.7	0.2	0.838	.
Per capita farm size	0.76183	0.7722	-2	-0.23	0.820	0.98
Kinship ties to chief	0.11034	0.1160	-1.8	-0.21	0.831	.
Kinship ties to headman	0.46897	0.4744	-1.1	-0.13	0.896	.
Kinship ties to FC	0.38966	0.3600	6.5	0.74	0.461	.
Distance to Amatheon (Km)	45.187	45.9720	-3.1	-0.38	0.707	1.11
Number of obs	967					
LR chi2(9)	106.43					
Prob > chi2	0.0000					
Pseudo R2	0.0900					
Log likelihood	-538.24929					

Source: Author's compilation from AAZ panel dataset

Table 24 shows that there is no difference in the impact of the AAZ support on both the treated and control groups on overall crop commercialisation this implies that both participants and non-participants have the same effect of the intervention on the marketing of cowpeas, sunflower, groundnuts, and vegetables. This entails that AAZ support increases crop commercialisation by 74.6% across participants and non-participants in the study areas.

Table 24: Impact of AAZ Support on Overall Crop Commercialisation

Variable sample	Treated	Controls	Difference	S.E.	T-stat
crop commercial unmatched	0.746078	0.69123	0.054848596	0.015408	3.56
ATT	0.745826	0.689403	0.056423076	0.014539	3.88

Source: Author's compilation

Maize is a staple crop in Zambia, forming a significant part of the country's diet and serving as a primary source of nutrition for the population (Burke, 2012; Mwiinga, 2021). Because of its importance as a staple crop, maize is a traditional crop and is produced by many households, especially those considering commercialising the crop. Maize can thrive in all agro-ecological zones of Zambia, making it a preferred choice for most smallholder farmers due to its ability to adapt to varying climatic conditions. The high demand for maize in both domestic and

regional markets makes commercialization more attractive when there is a consistent and substantial market for the crop. The government has existing policies, such as the Farmer Input Support Program (FISP), that support smallholder farmers with inputs and fertilisers to enhance productivity, making maize commercialisation more viable (Hichaambwa and Jayne, 2012). In addition, agricultural research and extension services that provide farmers with knowledge about improved farming practices can contribute to increased maize production and commercialisation.

It is not surprising that participant households in the AAZ out grower scheme are more commercialised than non-participants. This is attributed to the guaranteed off-take markets for smallholders, which encouraged commercialisation of the staple crop. Farmers who sell larger volumes of maize are more likely to generate higher incomes than those who mainly produce for consumption. Higher incomes generated from the commercialisation of maize help participant households bear the cost of consumption than non-participant households. Market-oriented production enhances incomes compared to subsistence production, making commercialisation a pathway to poverty reduction and increasing smallholder farmers' welfare (Muriithi and Matz, 2015).

CHAPTER FIVE- CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

This chapter presents the conclusion on the determinants of agricultural commercialisation in the AAZ out grower scheme using the Fractional Regression model and the impact of AAZ support on maize, soya beans and overall crop commercialisation. It also discusses the limitations of the study and provides policy recommendations based on the findings.

5.2 Conclusion

This study uses insights from a nucleus out grower scheme, Amatheon Agri Zambia to explore the main determinants of maize, soya beans and overall crop commercialisation and assesses the impact of LSAIs on smallholder agricultural commercialisation. The study used a logistic Fractional regression model to determine factors influencing smallholder commercialisation and the Propensity Score Matching to determine the impact of AAZ on smallholder commercialisation.

Results show a generally significant increase in commercialisation between the treatment and control groups at both study rounds. Further analysis revealed that most soya beans are farmed primarily for commercial purposes since baseline commercialisation rates were greater for both participants and non-participants. Soya bean sales reduced at follow-up from baseline to follow-up for participating households while for non-participating households, the sales decreased from baseline to follow-up and the difference was statistically significant. Two factors would have caused this decline in soya beans sales, the first one is that AAZ restructured its out-grower scheme to focus on more high-value crops like quinoa and bought more grains during its initial phase.

In addition to soya beans and maize, other crops such as cowpeas, groundnuts, sunflower, vegetables and fruits are grown in both districts and were used to calculate the overall crop commercialisation index. The proportion of farmers in both the treated and control groups increased during both study periods. The proportion of both the treated and control households sold over 75% of soya beans. For the staple crop maize, most farmers are medium commercialised with of treated and control households selling between 30-75% of their grains. This is attributed to the availability of buyers including AAZ that set up trading depots to purchase maize and soya beans from smallholder farmers to integrate them into the rural value

chains by acquiring grains through higher trading volumes. The proportion of farmers sold over 75% of cowpeas, groundnuts sunflower as well as fruits and vegetables indicating high commercialisation of the overall crops.

The results from the fractional regression model indicate that several factors determine smallholder agricultural commercialisation in the AAZ out grower scheme. These factors include household socio-economic characteristics, farm production factors, wealth indices, and program components. The main determinants of agricultural commercialisation are the age of the household head, ownership of agricultural assets, household wealth indices, average yield, farm gate prices, household size, distance to Lusaka, level of education of the household head, loan access from sources other than AAZ, and, receiving agricultural advice or training and selling grain to AAZ.

Finally, the study found that there were significant differences in maize commercialisation between the treated and control groups, implying that receiving support from AAZ improves smallholder farmer's commercialisation of maize by 61.08% compared to those who do not receive support from AAZ. There were no major differences between households that participated and those that did not participate in the study for soya beans and overall crop commercialisation. Across the treated groups, soya beans and overall crop commercialisation increased by 83.0% and 74.6% respectively. In the control groups, the increase was 82.85% for soya beans and 69.12% for overall crop commercialisation.

5.3. Recommendations

Given that the education level of the household head is a significant factor influencing participation in the AAZ out grower scheme, policymakers may consider investing in education programs in rural areas. Supporting educational initiatives can enhance the capacity of smallholder farmers to engage in and benefit from agricultural commercialisation schemes. Recognising that larger households are more likely to participate in out grower schemes, policies should be designed to specifically target and support larger households. This may include tailored extension services, financial assistance, or other incentives to encourage participation. Policies should encourage and facilitate the formation of cooperatives and trading groups among smallholder farmers. Group membership has been identified as a positive factor for participation in out grower schemes, indicating the potential benefits of collective action that may encourage crop commercialisation. In addition, given the influence of kinship ties to AAZ farmer coordinators, efforts can be made to strengthen and leverage existing social

networks within rural communities. This may involve community engagement programs, networking events, or initiatives that promote social capital. While distance to AAZ is not identified as a significant factor in participation, policymakers should ensure that infrastructure and transportation systems are in place to facilitate farmers' access to support programs. This can improve overall outreach and inclusivity. The study highlights the varying impacts of AAZ support on different crops (maize, soya beans, and overall crop commercialisation). Policymakers may consider tailoring interventions and support mechanisms based on the specific needs and characteristics of each crop. Given the dynamic nature of agricultural systems, policymakers should invest in ongoing monitoring and evaluation of out grower schemes. This will help assess the long-term impacts, identify any evolving challenges, and inform adjustments to policies and interventions. Strengthening agricultural extension services is crucial for disseminating knowledge on improved farming practices. This includes providing information on crop management, market dynamics, and the benefits of participation in out grower schemes. In as much as AAZ provided training to smallholder farmers in the study areas, the frequency of the training was not consistent as farmers were left hanging in the balance due to the abrupt discontinuation of the training. Furthermore, given the significant positive impact of AAZ support on maize commercialisation, there should be a continued and strengthened focus on providing targeted assistance, including training, resources, and market linkages, to smallholder farmers engaged in maize cultivation. AAZ and similar agricultural initiatives should consider expanding support mechanisms for maize production, addressing specific needs such as access to high-quality seeds, efficient farming practices, and post-harvest management. Recognising the lack of significant differences in soya bean and overall crop commercialisation between participants and non-participants, AAZ should consider diversifying its out grower scheme offerings to include a broader range of crops. The out grower scheme can benefit from incorporating crops with high market demand and profitability, thereby providing smallholder farmers with diversified income streams and reducing the dependency on a single crop. In summary, the policy implications emphasise the importance of a holistic and targeted approach to support smallholder farmers in out grower schemes. Tailoring interventions to the specific needs and characteristics of the local context can enhance the effectiveness of agricultural development policies.

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APPENDICES

Appendix A: Matrix correlation of shocks Variables

	flooding	drought	unusua~l	windst~m	crop_p~e	livest~e	bushfire
flooding	1.0000						
	581						
drought	-0.0988*	1.0000					
	0.0172						
	581	581					
unusual_ti~l	0.2928*	-0.0239	1.0000				
	0.0000	0.5660					
	581	581	581				
windstorm	0.1372*	0.0296	0.2822*	1.0000			
	0.0009	0.4758	0.0000				
	581	581	581	581			
crop_pest_~e	0.2544*	0.1595*	0.1963*	0.1072*	1.0000		
	0.0000	0.0001	0.0000	0.0097			
	581	581	581	581	581		
livestock_~e	0.3513*	0.0946*	0.2159*	0.1174*	0.4217*	1.0000	
	0.0000	0.0226	0.0000	0.0046	0.0000		
	581	581	581	581	581	581	
bushfire	0.1629*	0.0547	0.2208*	0.0655	0.0998*	0.1485*	1.0000
	0.0001	0.1877	0.0000	0.1148	0.0161	0.0003	
	581	581	581	581	581	581	581
priceincre~s	0.3466*	0.1353*	0.1557*	0.0778	0.3972*	0.4173*	0.1104*
	0.0000	0.0011	0.0002	0.0609	0.0000	0.0000	0.0078
	581	581	581	581	581	581	581
pricedecre~s	0.3500*	0.2025*	0.5108*	0.1906*	0.3055*	0.3911*	0.2625*
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	581	581	581	581	581	581	581

	pricei~s	priced~s
priceincre~s	1.0000	
	581	
pricedecre~s	0.3747*	1.0000
	0.0000	
	581	581

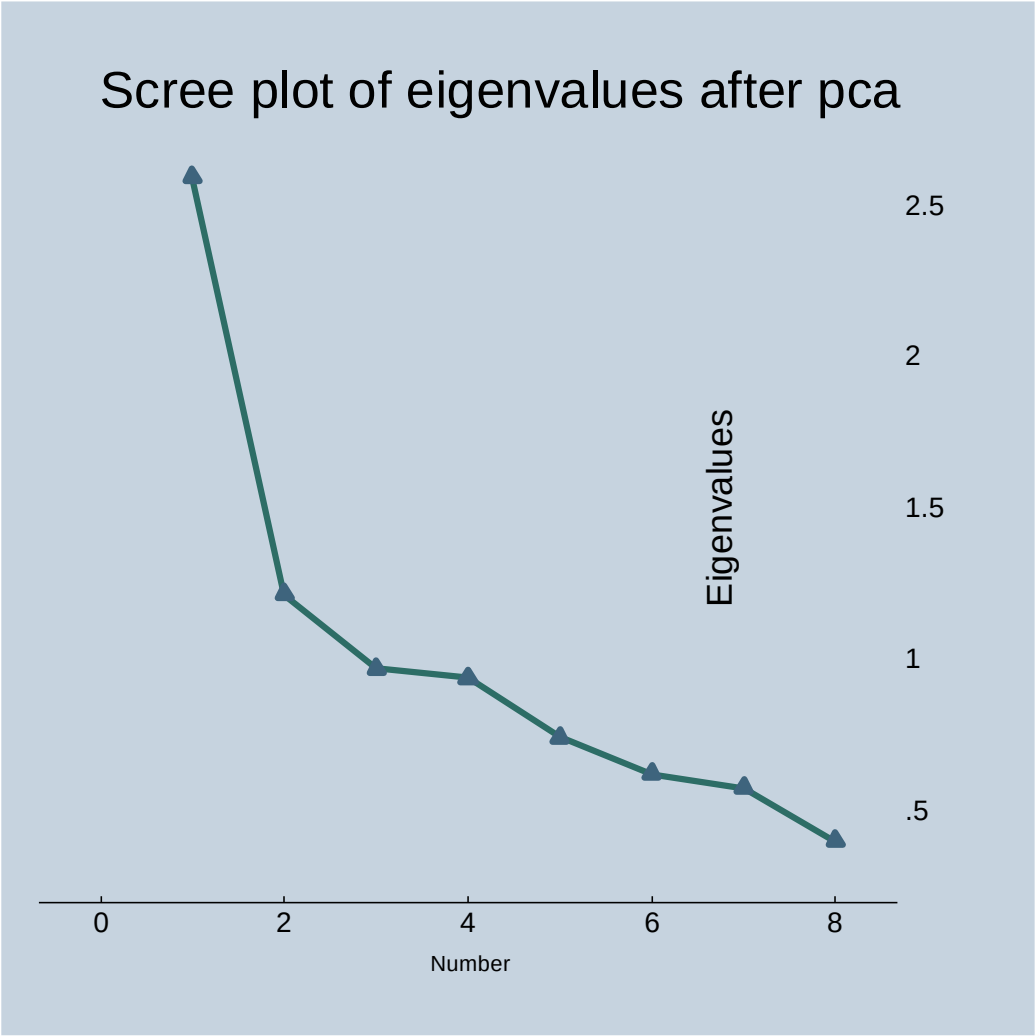
Appendix B: KMO Test of sampling adequacy

Variable	KMO
flooding	0.8043
drought	0.4639
Unusual timing of rainfall	0.6838
windstorm	0.7768
Crop pests and diseases	0.8107
Livestock disease	0.8187
bushfire	0.8567
Price increase of agricultural inputs	0.7978
Price decrease of agricultural outputs	0.7386
Overall	**0.7626**

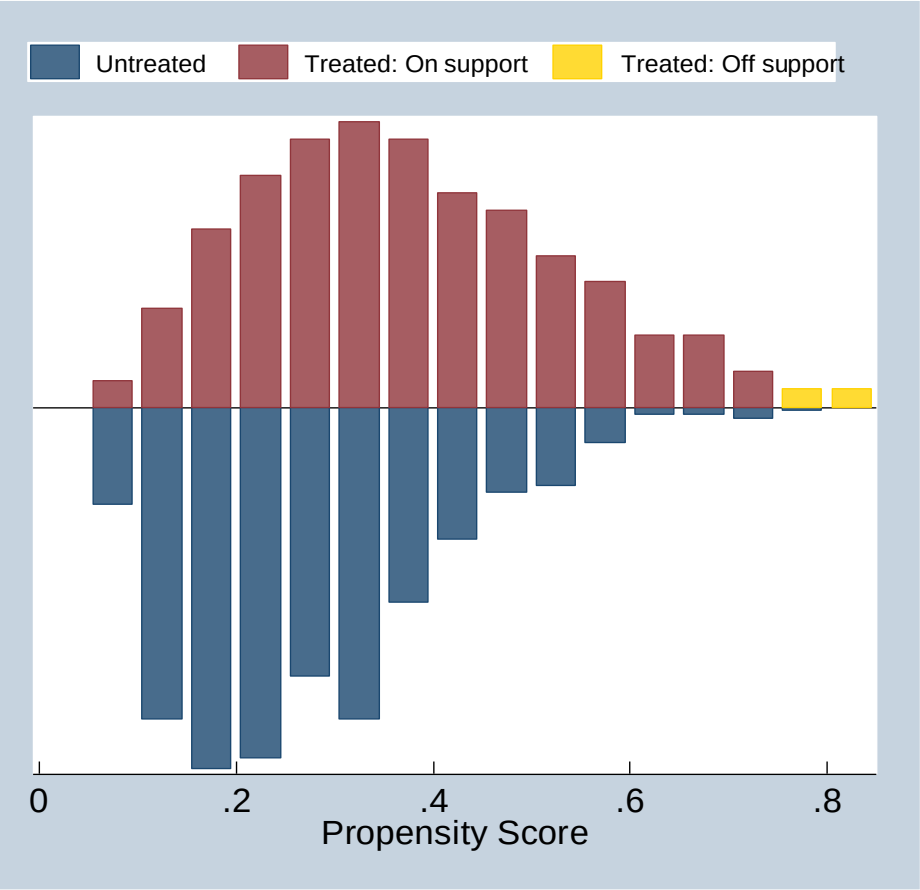
Appendix C: Coping strategies to shocks or Disruptions

What did you or your household do to cope with these shocks?	Frequency	percentage	Cumulative
Did nothing	273	50.84	51.21
Worked more	27	5.03	56.24
Diversified agricultural portfolio	18	3.35	59.59
Replanted the crop	6	1.12	60.71
Substituted crops (changed to less risky crops)	4	0.74	61.45
Reduced production inputs	49	9.12	70.58
Reduced household consumption expenditure	11	2.05	72.63
Sold livestock	34	6.33	78.96
Took children out of school	1	0.19	79.14
Sent children to relatives/friends	1	0.19	79.33
Sold assets	13	2.42	81.75
Sold stored crops	15	2.79	84.54
Used savings	30	5.59	90.13
Borrowed from family/ friends/ neighbours	8	1.49	91.62
Received help from government/ NGO/friends/family	13	2.42	94.04
Other, specify	32	5.96	

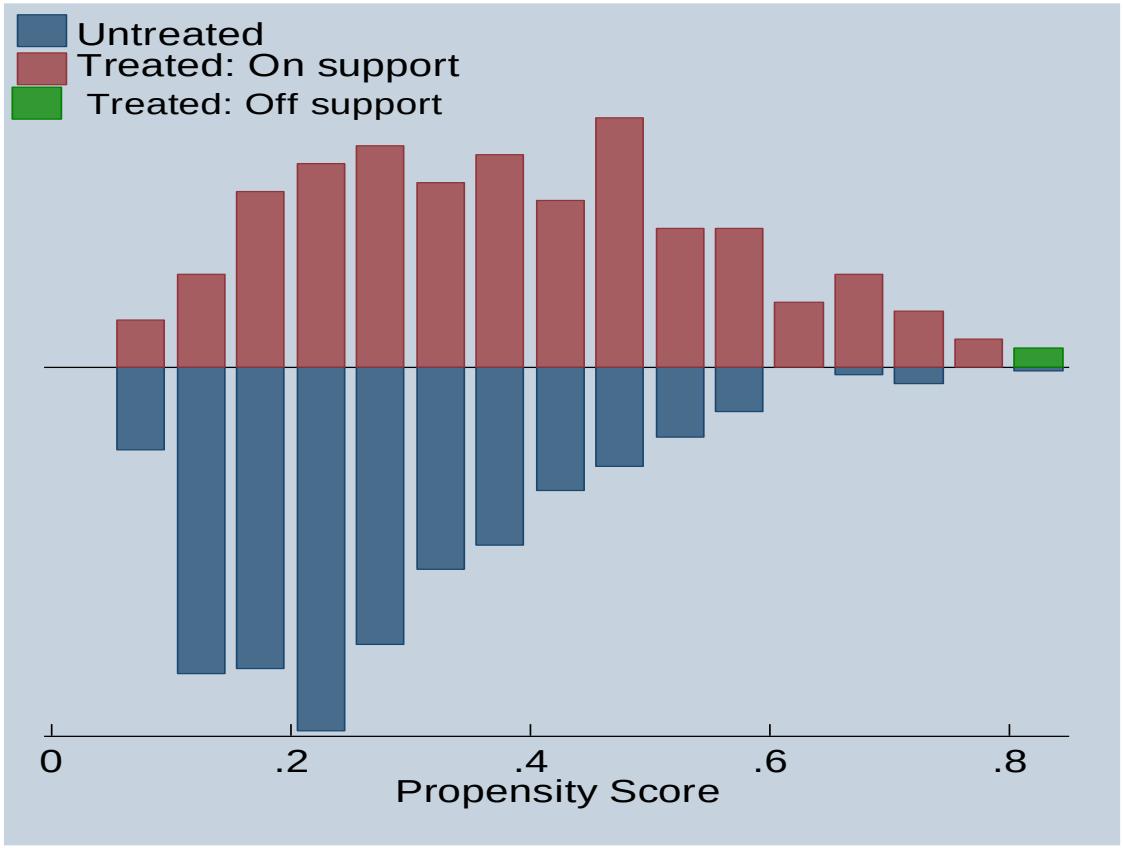
Appendix D: Scree plot of Eigen Values after PCA



Appendix E: Propensity Score Distribution and Common Support for Covariate Balancing for Maize Commercialisation



Appendix F: Propensity Score Distribution and Common Support for Covariate Balancing for Soya Beans Commercialisation



Appendix G: Propensity Score Distribution and Common Support for Covariate Balancing for Overall Crop Commercialisation