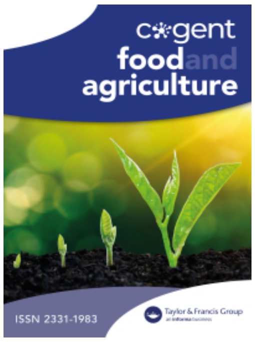

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Soyabean expansion and smallholder livelihoods in rural Zambia: dynamics, experiences and implications

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ABSTRACT

This study investigates how expansion of soyabean production enhances smallholder livelihoods in rural Zambia. Using a mixed-methods research design that integrates questionnaire surveys, focus group discussions, and interviews. The results show that a clear policy orientation has driven the expansion of soyabean production, which has been underpinned by market dynamics and private actors. Soyabean adoption among smallholders is top-down, and emphasizes income benefits among rural producers. Soyabean adoption enhances food security and provides wider benefits, including increased community, regional, and cross-border trade exchanges. Quantitative analysis shows that climate change adaptation of soyabean cultivation increases the probability of improved rural livelihoods of small-scale farmers in Zambia by 1.554 which is statistically significant at 0.05 significance level. However, the top-down nature of soyabean promotion raises questions about sustainability beyond current state policy and market dynamics. The hype around soyabean expansion has not been followed by significant smallholder improvements; hence, there is a need for capacity building in value addition and processing, including those that emphasize the nutritional dimensions of soyabean expansion.

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Development policy; rural development; environment & the developing world; sustainable development

1. Introduction

A significant transition is underway across sub-Saharan Africa, where both domestic and foreign capital drive soybean expansion. This has resulted in a new agrarian structure emerging from converting land into soyabean, which may lead to the expansion of agricultural frontiers (Gasparri et al., 2015). However, the focus on how this shapes land use and livelihoods of smallholder farmers has become an emerging area of research. Recent advances in soybean expansion generally consider that related investments among farmers also build resilience to climate risks. Climate impacts on agriculture through variable or increased rainfall patterns continue to re-organize production patterns, and actual processes on how rural producers adapt remain complex. Across Sub-Saharan Africa, national policy responses have advanced Non-Traditional Agricultural Exports and value chains, such as soyabean, which are connected to global chains as climate adaptation strategies and rural economic empowerment (Manda et al., 2019). Studies such as Kapulu et al. (2023) reveal that national policies aimed at increasing the promotion of soybean cultivation across Southern Africa can be linked to a broader international soyabean complex consisting of soyabean, soyabean oil, and soyabean meal. As one of the most heavily traded commodities in the world, global soybean cultivation has expanded at an average rate of 4.8% since 1990, with 71% of the growth attributed to additional harvested hectares in land area, while the other 29% has come from higher yields (Gasparri et al., 2015). In addition, growing demand from the livestock sector, propelled by the rapidly growing animal-feed-to-poultry value chain, has been an important driver for expanding soybean cultivation in Zambia. Although soyabean expansion continues to integrate small-scale farmers as producers, improve household economies and livelihoods remains under research.

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There are arguments that soyabean have a multiplicity of livelihood benefits to rural households. Soyabean, are the source of oil, meal, and soil nutrition, animal feed such as for the poultry sector, which has grown by 20% per year in Zambia (Siamabele, 2019: Munguzwe et al., 2014). Human consumption, in form of soy chunks and soy products like 'Yummy Soy,' account for the remaining 11% and is also one of the fast- growing sectors, expected to grow by 8% per year over the medium term to 2020 (Munguzwe et al., 2014). More broadly, the production area for soyabean cultivation has expanded rapidly to about 61.1 million hectares in 2016 from about 26.5 million hectares in 1966 and 121.5 million hectares in 2016 (Food & Agriculture Organization of the United Nations, 2017, Siamabele, 2019). Largely Brazil, the USA, and Argentina have contributed more to this expansion in response to the growing demand for feed in the livestock industry; however, Africa is equally on the move (Siamabele, 2019). The increasing demand for soybean also points to the expansion of meat production in China (ACET, 2013). Increased demand for vegetable oil consumption, both for food for the growing population and as a feedstock for biofuels (High Level Panel of Experts [HLPE], 2011), adds to the current soyabean cultivation dynamics.

In Eastern and Southern Africa, the soybean industry has been driven by demographic growth, expanding domestic demand for vegetable oil and soyabean as a feed for livestock (poultry) (Meyer et al., 2018). Within the region, soyabean cultivation has been promoted as drought-resistant amidst the continued changes in climate, coupled with its profitability potential among small-scale producers (Meyer et al., 2018). There is evidence that soyabean in East and Southern Africa will continue to expand, driven by regional and international imperatives (TechnoServe, 2011; Gasparri et al., 2015). In Zambia, a new soybean complex has emerged, with smallholders engaged in productive activities. As with countries in the region, favorable soybean prices and increased capital investments are driving land use (Siamabele, 2021). Soybean are not a new crop for Zambia. However, it was not until the mid-2000s that crop production grew exponentially driven by state policies and foreign and domestic off-takers who are introducing new technologies (Kapulu et al., 2023). As a result, many farmers are becoming increasingly connected to farming, taking risks of putting land into soyabean production. The opportunities and challenges that emerge for climate change adaptation and their wider implications remain an interesting area of research.

Using the case study of Zambia, this study investigates how and in what ways soyabean cultivation enhances smallholder livelihoods. Specifically, we ask:

a. Does soyabean cultivation enhance smallholder livelihoods in rural areas?
b. What are the wider implications of soyabean expansion among small-scale producers?

By doing so, we explore how top-down promotion of crops plays out within a national context, and what this means for poor farmers.

2. Soyabean expansion and rural livelihoods

Soyabean expansion enables a focus on actions that can improve livelihoods and reduce the negative impacts of climate change (Houghton et al., 2001; Intergovernmental Panel on Climate Change, 2013). This includes a focus on policies and actions that facilitate livelihood and climate resilience. Adaptation also considers changes in processes, practices, and structures to moderate potential damage or to benefit from opportunities associated with climate change (Siamabele, 2021). Climate change affects agricultural crop yields through alterations in temperature and rainfall cycles, as well as changes in soil quality, pests, and diseases (Bateman et al., 2018; Cruz et al., 2007; Smith et al., 2009) and which make soyabean expansion admirable due to its multiplicity effects. However, smallholder farmers often lack social, technological, and financial resources that enable them to adapt to these changes (United Nations Framework Convention on Climate Change, 2007).

Adaptation has become more than a requirement for sustainable development, considering that the majority of rural households depend on agriculture for their livelihoods Intergovernmental Panel on Climate Change, 2007). There are links between adaptation and sustainable development, such as poverty and livelihoods, food and human security on the one hand (Morgan & Farsides, 2017), and the balance in the relationships between society and nature (Brown & Frederick, 1983; Intergovernmental Panel on Climate Change, 2007; Mestre-Sanchís & Feijóo-Bello, 2008; Molua, 2009). Climate change heightens the pressure on land and water resources and even causes agriculture to enter a non-sustainable cycle of food production (Alcamo et al., 2007). However, appropriate adaptation measures can help reduce vulnerability and provide numerous opportunities for agriculture (Smit & Skinner, 2002; Wilk &

Wittgren, 2009). The applicability and success of various adaptation options are influenced by myriad factors (Bryan et al., 2009) and vary between regions and farms. Determining an adaptation option for a particular situation requires an assessment of its effectiveness, economic feasibility, flexibility, and institutional compatibility (Klein et al., 2014).

The ability of communities and individuals to respond to livelihood challenges is related to capacities and assets that typically overlap with indicators of development (Eakin & Carmen, 2006). For small-scale farmers, crops such as soyabean can improve food security and nutrition amidst climate change impacts (Eidsvoll, 2011, Davies et al., 2015). For small-scale producers, soyabean are arguably simple to grow with a short growing season compared to traditional crops, which is an attractive feature for national governments and donors concerned about climate change adaptation (Sinclair et al., 2014). The cultivation of soyabean offers an opportunity to diversify smallholder incomes, enhance food security, and complement carbohydrate-rich diets (Siamabele, 2019). Soyabean improve soil fertility when rotated with traditional crops, such as maize, driving environmental sustainability and maize yields when rotated together (TechnoServe, 2011). There are questions regarding how soyabean contribute to food security and livelihoods within climate extremes and risks. For example, in Zambia, the last two decades have shown high rainfall variability, negatively impacting traditional rain-fed crop production, such as maize, but how these dynamics play out for communities cultivating soyabean remains an interesting area of research (Indaba Agricultural Policy Research Institute (IAPRI), 2020).

We use the sustainable livelihood theory of Chambers and Conway (1991) to assess the assets and vulnerability of small-scale farmers and how the adoption of soyabean has enhanced their livelihoods. Rural livelihoods are understood in terms of people's assets and how they try to convert these assets into expected livelihood outcomes. Siamabele (2019) is of the view that the market for soybean products for human consumption, such as soy milk, chunks, burgers, sausages, hot dogs, mince, and polonies, but a few enhance rural households' food security by strengthening food availability, accessibility, utility, stability, and nutrition. Narrow livelihoods, as opposed to diverse livelihoods, can reduce livelihood resilience and climate adaptation. This study focuses on how soybean adoption shapes these elements. People need a variety of assets to create positive livelihoods, and no one category is enough to support the varied livelihoods people seek (Department of international development (DFID), 1999). These assets are commonly categorized as human, social, physical, financial, and natural capital (Ellis, 2014; Rakodi & Lloyd, 2002). It is understood that soyabean uptake enables farmers to elevate themselves from their vulnerable contexts. This relates to the activities, objectives, and goals that households engage in in in response to climate change. These elements are related and depend on the national policy environment.

3. Research design and methodology

3.1. Description of study sites

This study focused on the Eastern Province of Zambia, where the country continues to experience climate change and climate variability. The mean annual temperature in the country has increased by 1.3 °C since 1960, at an average rate of 0.29 °C per decade. Mean annual rainfall over Zambia has decreased by an average rate of 1.9 mm per month (2.3%) per decade since 1960 (Fumpa-Makano, 2011; National Adaptation Programme of Action, 2007; World Bank, 2020). The eastern province of Zambia, like most other provinces, has also been faced with climate change, directly implicating the livelihoods of rural households whose sustenance is dependent on rainfed agriculture. Poor productivity and distribution of food have largely resulted in problems of high malnutrition and hunger levels, making development stakeholders initiate adaptive mechanisms that can enhance the coping capacities of rural farmers (United States Agency for International Development, 2011). Coupled with many government interventions in response to climate change, the United States Agency for International Development (USAID) also implemented the Feed the Future (FtF) program in the Eastern Province to lift more than a quarter of a million rural people (mostly farmers) out of poverty by 2015 (United States Agency for International Development, 2011). The government has also rolled out the cultivation of soyabean among smallholder farmers in the region because of its multiplicity effect amidst climate change implications. With the multiple effects of soyabean cultivation, this study examined how the adoption of this crop has positively influenced rural farmers' livelihoods. The multiplicity effects of soyabean include benefits to the production systems, diets, incomes, profitable cash crops, and high protein content (approximately 40%) (Dixit et al., 2011; Lubungu et al., 2013).

This study was limited to the Chadiza, Chipata and Mambwe Districts of Eastern Province of Zambia (Figure 1). These areas have been targeted by international donor organizations, such as USAID, as frontiers of soybean expansion. The affirmative policy on the Feed the Future (FtF) program of soyabean cultivation aimed at lifting more than a quarter of a million rural people (small-scale farmers) out of poverty by 2015 (United States Agency for International Development, 2011). The study area is located between the latitude of 13°40′00.0"S (−13.6666700°) and longitude of 32°00′00.0"E (32.0000000°). The average elevation of the Eastern Province of Zambia is 818 m (2,684 ft) above sea level (World Meteorological Organization, 2019). With the provincial capital of Chipata, Eastern province has an area of 51,476 km^2 (19,875 sq mi). Smallholder farmers in this province have largely been cultivating maize, groundnuts, sunflowers, and cotton, but due to climate variability in terms of rainfall and temperature parameters impacting farmers' productivity, some farmers have shifted to drought-resistant crops, such as soyabean and other legumes. The shift in soybean cultivation by small-scale farmers has also been due to a number of agronomic and nutritional attributes, in addition to being a drought-resistant crop (United States Agency for International Development, 2011).

Eastern province was chosen as it has many smallholder farmers in soyabean cultivation, which would help the study inform policies. The increased demand for soya products means that most small-scale farmers will continue to adopt soyabean as drought-resistant crops (Indaba Agricultural Policy Research Institute (IAPRI), 2020). The exponential adoption of soyabean observed after 2010 has seen a significant investment in the Zambian oilseed,

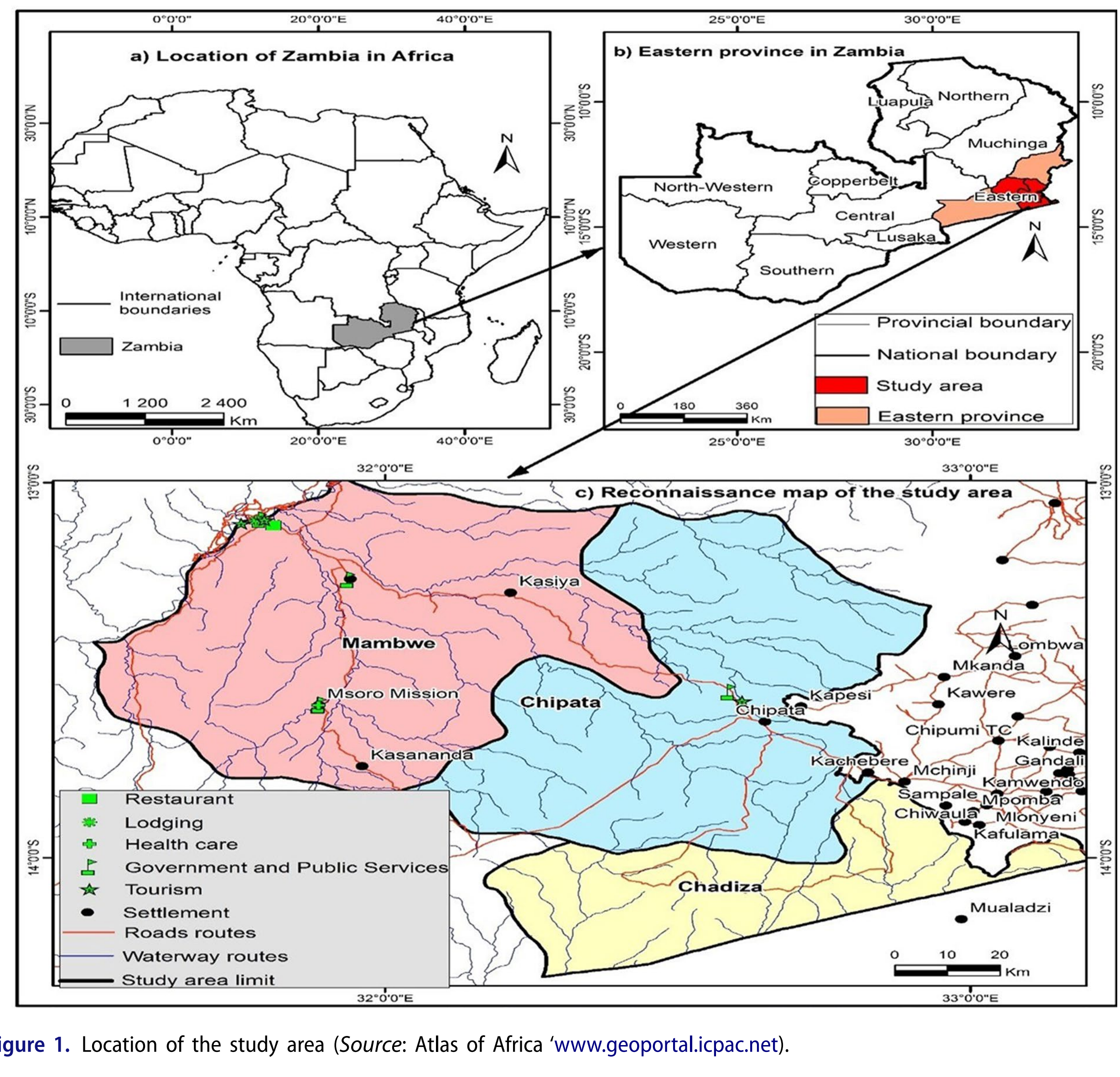

Figure 1. Location of the study area (*Source*: Atlas of Africa 'www.geoportal.icpac.net).

which expanded the total crushing capacity from 125 thousand tonnes in 2010 (TechnoServe, 2011) to approximately 375 thousand tonnes in 2013.

3.2. Methods

The target population for which the sample size was selected in this study included those directly and/or indirectly affected by the adoption of soybean cultivation in the study area. These included small-scale farmers, community leaders, district officers, the Ministry of Agriculture, Research Institutions, and civil society organizations.

3.2.1. Qualitative sources

This study adopted a mixed methods design. Qualitative elements focused on the perceptions and opinions of the respondents regarding the adoption of soyabean cultivation as climate adaptation and implications for livelihoods. We used interviews and Focus Group Discussions (FGDs), as well as observations. First, we conducted 53 interviews at both the community and institutional levels. Interviews were held with key informants such as village headpersons, health officials, district agriculturists, and officers from the Ministry of Agriculture, including research institutions such as the Zambia Agricultural Research Institute. We used interviews to ask specific questions about drivers of expansion, actors, and implications. Second, a total of nine (3 per district with two districts-Chjipata and Chadiza as oldest in soya production and Mambwe District being newest) focus group discussions were held with about seven to ten members in each group, paying attention to age and gender (youth, women, and men). We also held two group discussions (one with widows and one with widowers) in each district. These FGDs were purposively composed of a holistic view of soybean cultivation and rural livelihoods. We used group discussions to reflect on the wider implications of soybean expansion in communities, local views, and perspectives. We also use observations to explore asset acquisition and livelihood activities in local communities. To record the interviews and FGDs, the researcher ensured ethical considerations and the adherence of respondents' rights during and after the interviews.

3.2.2. Quantitative data sources

The study included 384 respondents (small-scale farmers as the primary target group and key informants inclusive). The sample size was evenly distributed across the districts of focus drawn from different agricultural camps. The sample size was purposively evenly drawn from three districts of focus, each with 111 participants (56 females and 55 males, giving a total of 188 males and 196 females in the whole study). Studies have revealed that the number of women engaged in agriculture with respect to soybean production has increased in this region. This is drawn from the multiple opportunities offered by soyabean and their capacity to enhance food accessibility. This informed the purposeful justification for having the same number of women and men in this study. Quantitative design statistically evaluates changes in income, employment, market access, and productivity in terms of supply and demand locally and regionally, and how these relate to soyabean uptake (Amungwa, 2020). Approximately 331 questionnaires were administered to small-scale farmers across the districts of study. The total number of target households (which is the population in this study) or the people involved in soyabean cultivation were unknown; therefore, this study calculated the sample using the infinite sample size selection formula by Kothari (2011).

$$n = \frac{\left(Z^2\right)p\left(q\right)}{e^2}$$

Where: n= sample size Z=95% (1.96) [the value of standard variate at a given confidence level and to be worked out from table showing area under the normal curve] P=0.5 [sample proportion] e=5% (0.05) [given precision rate or acceptable error] $q=1-p$ $(1-0.5)$.

Sample size then will be calculated as follows:

$$n = \frac{\left(Z^2\right)p\left(1-p\right)}{e^2}$$

$$n = \frac{(3.8416)(0.25)}{0.0025}$$

$$n = \frac{0.9604}{0.0025}$$

$$n = 384.16$$

$$n = 384$$

A total of 306 participants completed the questionnaires. Overall, 79.4% of respondents were married, 4.2% were single, 9.5% were divorced (n=29),

Table 1. Marital status of the respondents (survey participants 2020).

		Frequency	Percent
Valid	Married	243	79.4
	Single	13	4.2
	Divorced	29	9.5
	Widow	18	5.9
	Total	303	99.0
Missing	88	3	1.0
Total		306	100.0

5.9% were widowed ($n = 18$), and 95.8% ($n = 243$) were married (Table 1).

About 17.3% of the households surveyed had 6 members in a household, 16% had 7 people in their household and 14.4% had 8 people in their households. More broadly, household members ranged from 1 to 22 members. About 16% of the respondents had approximately seven members in a household, and 17.3% had approximately six members in a household.

3.2.3. Data organisation and analysis

Qualitative data were thematically analyzed, and the process involved consistently listening to the tape recordings. Audio recordings were transcribed verbatim. A coding system was developed and employed for all transcripts to reduce and organize the data and to extract quotes that were assigned to various code themes or categories. We used the assigned text categories to address our research questions.

Quantitative data were analyzed using descriptive statistics to produce pie-chats and bar graphs, and driven by a key hypothesis: climate change adaptation of soyabean cultivation does not affect the livelihoods of small-scale farmers. To test the hypotheses, the study aggregated the sum of the various items in each construct and performed a binary logit regression analysis after testing the internal reliability of the constructs using Cronbach's alpha. This approach has been deployed in similar studies, such as the one conducted in Kano State, Nigeria, by Murtal et al. (2018) on the effect of agricultural extension services on poverty reduction among members of farmers' cooperative societies. We then identified and retained three farmer livelihood measures, with an internal reliability coefficient (Cronbach's alpha) of 0.643. The farmer livelihood items retained included: (i) farmers bought household goods using sales from soyabean; (ii) soyabean cultivation has increased farmers' incomes and made it easier for them to meet their food security, social services, etc.; (iii) soyabean cultivation has enhanced farmers' ability to re-invest in livestock production, and separate binary logit regression models were run for each retained livelihood item. To do this, we express the following simple econometric models to determine the effects of the independent variable on the dependent variable:

$$LF = \beta_0 + \beta_1 CCA + \beta_2 AGE + \beta_3 EDU + \beta_4 NPH + \beta_5 YSF + \varepsilon$$

Where: *LF*: livelihood of small-scale farmers; *CCA*: climate change adaptation; *EDU*: level of farmer's education; *AGE*: age of farmer; *NPH*: number of people in household; *YSF*: number of years in soyabean farming; *E*: the error term.

3.2.4. Ethical consideration

The following ethical issues were considered during research; informed consent, avoidance of harm, confidentiality, and anonymity, privacy, truth and deception, conflicts of interest, power relations. An official letter was issued by the Institute of Governance, Humanities and Social Sciences of the Pan African University, and this facilitated the attainment of the ethical clearance from the University of Zambia and cleared the commencement of the fieldwork. All the participants were assured of anonymity and utmost confidentiality to solicit their free participation in the study. The respondents were assured of neutrality of information provided in the course of the study emphasizing that the results would be used only for academic purposes. The necessary steps were taken and informed consent of the respondents was made verbal before they participated in the research.

4. Results

4.1. Soyabean expansion and policy mechanisms

Multi-level interviews with state and non-state actors frequently expressed the view that for over five decades, Zambia failed to capitalize on the country's agricultural resources. Investment promotion hubs, such as the Zambia Development Agency (ZDA), advertise abundant resources, such as about 32% (of 75 million hectares of total land area) arable land. The country also boasts favorable climatic conditions for diverse crops, enabling crop diversification.

Since 2015, soyabean have assumed growing importance in Zambia's policy and practice for small-scale farmers against other crops in the region (Figure 2). The significance of soyabean production to rural farmers has advanced alongside

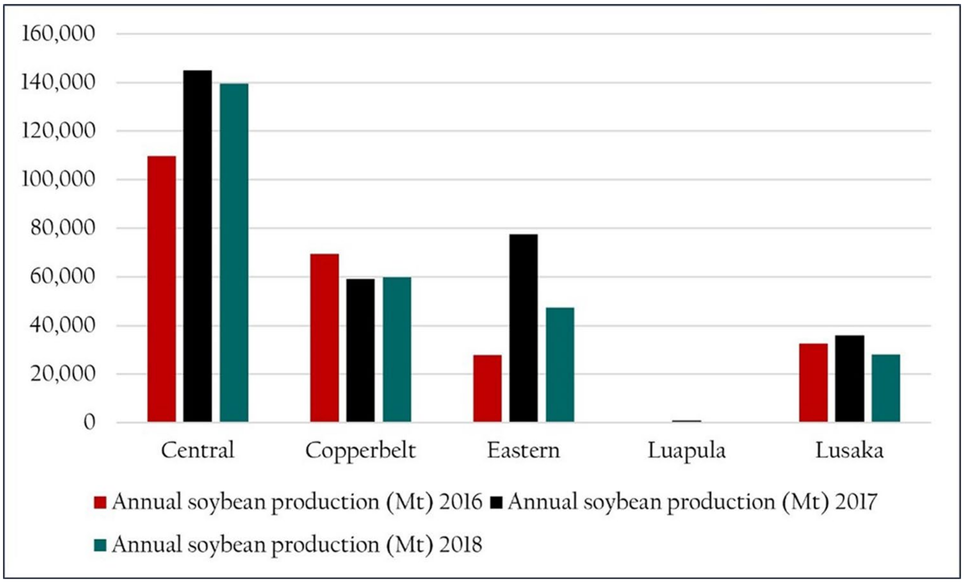

Figure 2. Major soyabean production provinces in Zambia (ZAMSTATS, 2020).

agricultural-growth narratives, the latter effectively embedding processes around agribusinesses (Manda et al., 2019; Siamabele, 2021). Approximately 40% of soyabean are produced by small-scale farmers, cultivating between one and five hectares of land.

The national agricultural policy in Zambia provides policy guidelines for expansion and development of the agricultural sector. These policies aim to enhance smallholder market linkages by extending subsidies to crops, such as soyabean, rice, and cassava (GRZ, 2016). National policies around legumes also promote investments (including foreign ones) while supporting research and extension services and sustainable resource use, including irrigation. There is a strong focus on national policies and political narratives on agro-processing, agricultural marketing and trade, livestock, and fishery development (Table 2). Sector and economic diversification logic is also central, encouraging farmers to diversify crop production as a strategy towards improving incomes and empowering rural populations (Manda et al., 2019). Since the 1960s, Zambia's agricultural sector has been maize-centric in terms of both policy and practice. Soyabean have been promoted as part of a national strategy towards a wider national diversification agenda beyond maize.

A critical review of national agricultural-related policies shows the prioritization of (1) economic diversification, (2) increased rural incomes, (3) poverty reduction, and (4) value-chain integration. Within this narrative, state and non-state actors encourage rural farmers to cultivate crops with high market demand that are relatively suitable for changing climates. Soyabean cultivation (enhanced value-chain integration) drives economic diversification, while enhancing rural incomes and ultimately reducing poverty – triple gains.

Table 2. Key policy documentation underpinning soyabean expansion in Zambia.

Document	Description
Africa Agenda 2063	Long-term development plan
Southern Africa Development Community-Regional Agricultural Policy	Regional policy plan
Vision 2030	Long-term development plan
National Agricultural Policy	Agricultural policy
National Agricultural Investment Plan (NAIP) 2014–2018	Investment plan
Strategy for industrialization and job	Industrialization strategy
National irrigation policy and strategy	Irrigation strategy
Fifth National Development Plan	Development plan
Sixth National Development Plan	Development plan
Revised sixth National Development Plan	Development plan
Seventh National Development Plan	Development plan
Zambian soyabean production manual	Ministry of Agriculture manual

A somewhat perfect market dynamic underpins soyabean expansion in Zambia, 'increasing alongside expanding livestock (including poultry and animal feed) and edible oils sector' (national key informant interview). Specifically, there are off-takers, such as ETG, AFGRI, and Ally and Son Limited. Interviews with Government Officers revealed that 2006 and 2009, soyabean production increased from 57815 MT to 281389 MT (320% increase). State marketing entities particularly the Food Reserve Agency (FRA), also play important roles in the market. FRA aims to administer strategic food reserves, engage in market facilitation, and develop and manage national storage facilities, which have driven exponential growth in the production and marketing of soyabean. The Zambian government sees this as an opportunity for triple gains, further committing through the supply of soybean seed and fertilizer as subsidies as part of the Farmer Input Support Program (FISP). The FISP was formulated with the purpose of ensuring timely, effective, and adequate supply of agricultural inputs to targeted small-scale farmers and improving farmers' access to agricultural inputs across a number of crops, including soyabean. Around 2014, soyabean were made part of the FISP, incentivizing smallholder production. However, small-scale producers are just a part of the multi-level actors that have shaped the soyabean value chain in Zambia. There are input suppliers that exploit seeds and fertilizers (e.g. Corporations such as SEEDCO and Syngenta, including local companies such as ZAMSEED), but some small-scale farmers still reported using recycled seeds. Medium- and large-scale producers produce approximately 60% of soyabean in Zambia. Combined, these have been linked to different aggregators that have links to processors, such as those in edible oil processing, livestock feed processors, and human food processors (e.g. Mt. Meru, ETG).

Government officers expressed views that favorable regional trade policies ensured better prices for local producers who were tapping into opportunities. In the study area, traders reportedly traded soyabean in Malawi and Mozambique, with many others targeting markets in the capital city of Lusaka. Small-scale farmers interact with diverse agents, but the frequent need for quick cash and poor market coordination arrangements means that they also face exploitative prices.

4.2. Livelihood basis for soyabean expansion

It is argued that soyabean adaptation has largely been underpinned by input and market dynamics. We view soyabean expansion and its implications for livelihoods through the lens of food availability, access, utilization, and stability (physical/economic). This view helps in understanding the extent to which soyabean production expansion influences the food security of rural households that have weak or no fall-back strategies when hit by climate change.

4.2.1. Soyabean adoption among rural producers

The results showed three main drivers of soybean uptake among farmers. The first aspect is *food security*. Small-scale farmers have adopted soyabean as a pathway to address several agricultural problems. Focus group discussions showed that a large majority of household discussants (80%) struggled with food availability and access. They reported low agricultural productivity, in part due to reliance on maize, which has recently been affected by droughts and rainfall variability. However, others reported that they grew soyabean because of 'the potential of the crop to supplement household food availability' (key informant interview 2021). The second factor is *climate adaptation and market dynamics*. A large majority of respondents (89%) indicated that changing climates (e.g. droughts) negatively affected agricultural production, forcing farmers to adopt soyabean now that support from the government is available and the market is good. Farmers reported a general reduction in maize production (based on the number of maize harvest bags), whereas others reported a drop in maize yields of approximately 25%. This has been compounded by the lack of irrigation systems in times of drought and expensive inputs for traditional crops. Farmers face poor market opportunities and low market prices for traditional crops, which have been compounded by continued state intervention.

Nearly all respondents grew sorghum, sunflower, cotton, groundnut, and maize. Meanwhile, respondents in the study expressed views that traditional crops such as the stapple crop (maize) require a lot of rain compared to soyabean. In response to climate risks specifically, most of the farmers responded by adopting drought resistant crops like soyabean, 'which can be cultivated within a short period of time and has high market demand' explained one District Officer. It was also found that despite the boom and burst in soyabean prices in some seasons, farmers would still make marginal profits when compared to maize, which has many challenges as it does not add soil fertility amidst climate change when inputs are too expensive to rural households. The final element was the income and profitability potential of the crop (100%). Farmers frequently associate soyabean with high market demand, high prices, and improved incomes. The income perspective of soybean adoption among smallholders is consistent with national policy narratives. Improved incomes enhance rural households' capacity to purchase food items that are not available in their households to improve food security and nutrition.

4.2.2. Food availability

Before adopting soyabean, 54.6% of the farmers reported that they relied on two meals a day, compared to 33.7% who reported that they could afford three meals a day, with 11.8% averaging a single meal a day. After adopting soyabean, the majority (84%) of the farmers reported they have been able

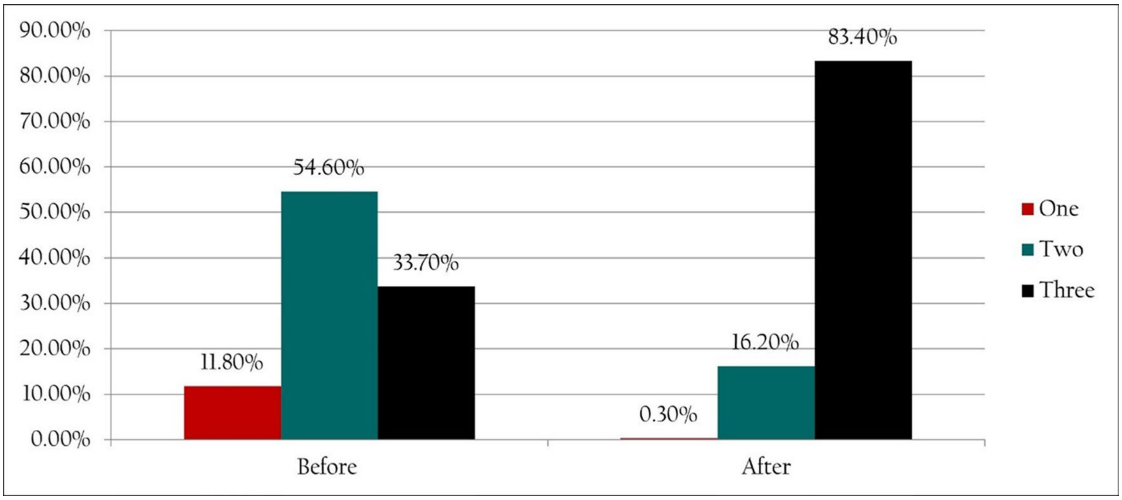

Figure 3. Comparing number of meals households had before and after starting growing soyabean .

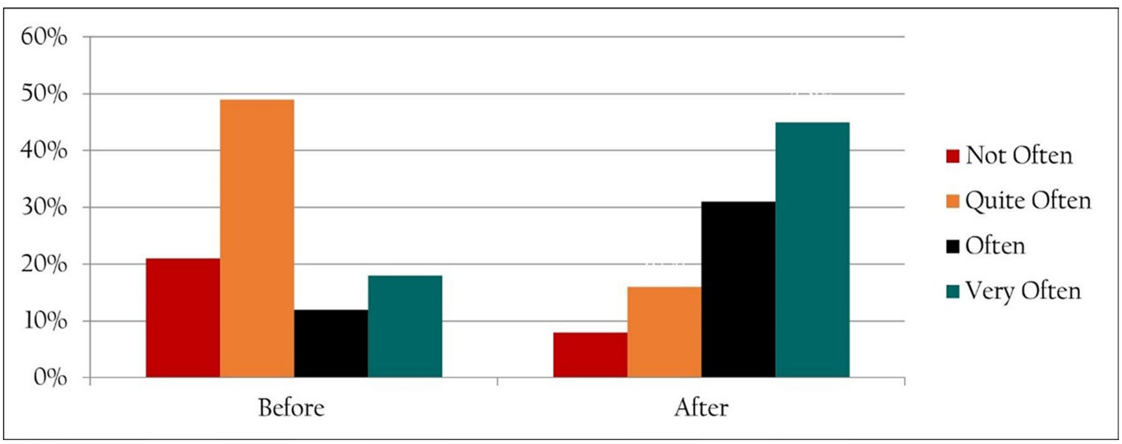

Figure 4. Access to healthy food after soyabean adoption.

having three meals a day, 16% reported averaging two meals a day, and less than 1% of the respondents relied on one meal per day (Figure 3).

Group discussions and community interviews across study sites argued that families that did not cultivate soybean faced food availability challenges. Group discussions of non-soyabean-growing households indicated that they frequently borrowed food from soyabean-growing households. Growing maize alongside soyabean has increased physical and economic access to food. The argument was that families in soyabean cultivation had a lot of available food in their households and income to use during periods of low food supply and availability or for trade exchanges.

Before soyabean adaptation, the majority of small-scale farmers (70%) indicated that their incomes did not allow them to manage their balanced diets. However, after adopting soyabean, most of the farmers (76%) indicated that they had been empowered financially to some extent due to its ever-growing market despite the price fluctuations, and are now somehow able to have a balanced diet (Figure 4).

Specifically, the adoption of soyabean has enhanced farmers' access to and utilization of soyabean (76%). However, analysis showed that non-soyabean growers were 2–3 times more likely to experience food consumption pattern challenges, and this was attributed to having less income from their staple crops in comparison to soyabean growers.

4.2.3. Food utilization, diversity and nutrition

Soyabean growers consume soyabean by cooking them in various ways. Soyabean cultivation not only improves income levels but also strengthens farmers' purchasing power, including food utilization. Soyabean adoption leads to crop diversity, thereby improving nutritional security.

> ….soyabean has been a miracle crop to my family as we able to realize some incomes even from as low as five 90kgs bags when compared to 90kgs maize bags. My family is now able to have a balanced diet due to these incomes. From the little we get from soyabean, we can go to the market and buy dry and fresh fish, powdered and fresh milk, rice, including cooking oil. My children are now able to eat bread and drink tea just like those in urban areas (Female Group Participant).

However, the levels of household processing of soybean remain relatively low, raising the need for policy responses that can emphasize the nutritional security of soybean expansion in Zambia. Farmers frequently reported improved nutritional security, which is defined as diversity in food availability. Meanwhile, rural health centers deliberately promoted household processing, and the consumption of soyabean explained to one District Health Officer. In Zambia, it is now mandatory for rural health centers to sensitize people to consuming diverse foods, including those rich in proteins. However, a lack of technology limits the extent to which households can consume soybean (100%). Among small-scale farmers, soybean is consumed either pound or ground using local grinding mills to produce soybean porridge. In some cases, farmers eat soyabean greens alongside Nshima, Zambia's staple.

4.2.4. Improvement in incomes

Soyabean are generally considered to be outliers among crops grown by small-scale farmers because of their high and steady prices. Soyabean prices have shown an upward trend. Through competitive market prices, farmers are able to sell soyabean and use their income to purchase other food staff from around the communities or nearby urban markets. In some cases, soyabean growers had opportunities to trade raw beans with non-soyabean growers with crops that they may not have produced. The results indicate that the cultivation of soyabean enhances farmers' income. Before soyabean adoption, the majority (68%) of farmers were only able to earn incomes below ZMW2000. Unlike before soyabean cultivation, more than 58% of farmers reported that they were now able to make more than ZMW10 000 Kwacha or more per season (Figure 5).

The majority of farmers (92%) strongly agreed that soyabean improved income, which led to stability in food availability and access. Soyabean have enhanced economic access to food indirectly through their ability to purchase market commodities (economic access to food). This logic was consistent with MoA Officers who argued 'cultivation of soyabean is enhancing the food security levels of the small-scale farmers in Zambia because the crop has a competitive market for improved incomes'. The argument by most of the respondents was that, cultivation of soyabean compared to the traditional crops like maize, cotton and tobacco has a lot of market due to its multiplicity purposes. Multiplicity purposes increase the capacity of rural households to earn income, which acts as a push factor in the cultivation of soyabean.

4.3. Wider implications of soyabean expansion

There are several wider implications of soybean uptake among small-scale producers and their communities.

First, we observed that households whose incomes increased acquired more assets compared to those that were not in soyabean cultivation. This is because, when compared to before adopting soyabean cultivation, most (70%) of the farmers only had limited

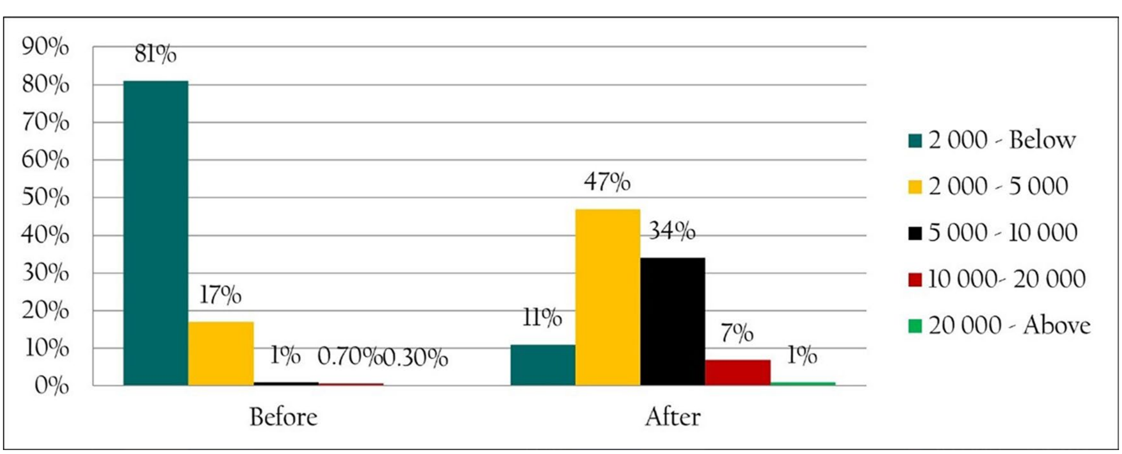

Figure 5. Small scale income levels 'before and after cultivating' soyabean.

assets such as hoe, not more than five chickens, and the houses were grass thatched. However, after adopting soyabean, more than 60% of the farmers have televisions, modern beds, more than 10 chickens, more than six goats, at least three cows or more, modern loafed houses, and plows that they use to cultivate (10% rise in asset acquisition).

Group discussions revealed that most participants used soybean income to acquire new technologies such as solar panels and water pumps. For example, a village headman in Chadiza District indicated that his people were now able to buy a plow, oxen for planting soyabean, and machinery to grind sunflower for cooking oil in their households. The results show that farmers across the districts had acquired many assets, with Chipata and Chadiza having the highest in re-investing soyabean incomes into livestock (goats, sheep, cows, and chickens) at 48 and 55%, respectively. Mambwe District leads (45%) in the purchase of household goods such as televisions, radios, seating room seats, phones, pots, cooking stoves, kitchen plates, clothes, beddings, and beds.

Second, soyabean cultivation impacted membership organizations, increasing the ability of farmers to join membership organizations by more than 40% when compared to before farmers adopted soyabean (less than 5%). This includes women who are frequently organized around different social initiatives. Women specifically argued that income realized from the cultivation of soyabean made it possible for them to make individual subscriptions into social groupings like Village Banking, but this is more common among women than men.

Third, group discussions revealed that soyabean improved the local trading systems between and among small-scale farmers. Non-soyabean growers traded maize for soya, and vice versa. Owing to soyabean cultivation, small-scale farmers have seen an influx of private soyabean buyers in their communities, which has brought the market to their door step. Such an influx of private buyers has helped address marketing challenges and brought about income stability among small-scale farmers, even though some of these buyers, especially those from across the border, tend to exploit farmers on prices. However, soyabean increased trade exchanges (within and outside communities, and enhanced incomes). Some better-off farmers used soyabean to exploit opportunities in cross-border trade, entering Malawi and Mozambique. Trade exchange included cash exchanges, but also exchanged soyabean for food commodities needed for household food security and nutrition. Exchanges with cooking oil and other carbohydrates giving foodstuff like rice and bread were common, seen as granting rural producers a taste of modern life and food diversity. However, cross-border trade remains informalized as small-scale farmers fear paying related fees (e.g. border tariffs), including when their produce is impounded by police officers. There is a need to 'facilitate small to medium scale trading enterprises and across the two borders' in the face of the African Continental Free Trade Area.

Fourth, intra-household relationships are reportedly changing because of improved financial flows and stability, transforming household power dynamics. Group discussion women argued that before growing soyabean, their husbands did not give them enough respect, mainly because of unclear economic contributions in the households. This arguably changed with soyabean adoption, arguing 'men automatically started giving us respect and listening to us'. Men discussion groups argued that, in their tradition, they were the ones to keep incomes and dictate utility in the households, and this was worse before women engaged in growing their own soyabean independent of their husbands. This was informed by a lack of access to income from family grown crops, such as maize.

Fifth, it includes expanding livelihood enterprises and general portfolios. Others (better-off farmers) used soyabean income to invest in businesses such as poultry, piggery, and vegetable gardening, further improving their incomes (stepping out).

Sixth, a few respondents pointed to soyabean's ability to improve soil fertility and ease of cultivation, which allows women to easily become producers with no expenditure on fertilizer. Some of this is related to soil fertility and intercropping/crop rotation. Soyabean were seen as having improved farming practices, as they allowed soil fertility, intercropping, and crop rotation practices. It also directly improves the cultivation of other crops, such as maize and other traditional crops (soil fertility). Overall, farmers saw the cultivation of soyabean as having reduced their dependency on maize, which promoted narrow as opposed to diversified livelihoods. However, there are questions about the sustainability of soybean expansion beyond the current state policy and market dynamics.

4.4. Testing the hypothesis

To understand how climate change adaptation in soyabean cultivation affects the livelihoods of small-scale farmers in Zambia, we tested the following hypothesis:

> H_0-Climate change adaptation of soyabean cultivation does not affect the livelihoods of the small-scale farmers.

We identified and retained three farmer livelihood measures, with an internal reliability coefficient (Cronbach's alpha) of 0.643. The farmers' livelihood items were: (i) farmers bought household goods using sales from soyabean, (ii) soyabean cultivation increased farmers' incomes, and (iii) soyabean cultivation enhanced farmers' ability to re-invest in livestock production. To determine the effects of climate change adaptation of soybean cultivation on livelihood items, we ran separate binary logit regression models for each retained livelihood item. The binary logistic regression results for farmers buying household goods after selling soybean are shown in Table 3.

The results show that while males are more likely to buy household goods after selling soyabean than their counterpart (female), this effect is not statistically significant. The level of primary education and above significantly affects farmers' purchases of household goods using income from soyabean production in all scenarios at $p<0.05$ in the first and second scenario with $p<0.10$ in the third, fourth, and fifth scenarios, respectively. For instance, in the first scenario, education increases household good purchases by 1.602 for respondents who were of a primary and above level of education compared to those who had not attended any school. When the years of planting soyabean were squared, the results showed that this increased the purchase of household goods by 1.005 at $p<0.05$. Owning land has been found to increase the buying of household goods by 2.015 more than if it did not own land. The adoption of conservation farming increased the buying of household goods by 1.554 at $p<0.05$. Adaptation to climate change using animal husbandry and drought-resistant crops increased the purchase of household goods by 2.123 and 1.970, respectively. The use of gardening as an adaptation strategy to climate change increased the purchase of household goods by 1.201. Therefore, climate change adaptation strategies increase farmers' purchase of household goods, except for planting, according to the onset of rainfall. As such, the null hypothesis (climate change adaptation of soyabean cultivation by small-scale farmers negatively affects livelihoods when livelihood is measured by the ability of small-scale farmers to buy household goods) is rejected (Table 4).

The binary logistic regression results for farmers with increased income after selling soyabean are shown in the table above. The results show that while the male gender has positive odds for increased incomes after selling soyabean compared to their counterparts, this difference is not statistically significant. The odds for primary education and above increased income in all the scenarios. The $p<0.05$ in the first, second, and fifth scenario while $p<0.1$ in the third and fourth scenarios, respectively. For

Table 3. Effects of climate change adaptation of soyabean cultivation on the livelihoods of small-scale farmers: (1) farmers bought household goods using incomes realized from sales of soyabean, binary logit regression results.

	OR	*OR*	*OR*	*OR*	*OR*
Gender (male)	1.548 (1.455)	1.615 (1.587)	2.771 (2.567)	1.872 (1.398)	2.745 (2.245)
Primary education level and above	1.602** (0.0755)	1.615** (0.0822)	1.524* (0.0947)	1.606* (0.0898)	1.715* (0.0996)
Years of planting soyabean– squared	1.005** (0.0125)	1.221** (0.0566)	1.688* (0.0821)	1.334** (0.0279)	1.946** (0.0557)
Owns land for farming soyabean (yes)	2.015** (1.226)	2.994* (1.532)	1.948*** (0.0869)	1.397* (0.0842)	2.116* (1.099)
Adaptation using conservation farming methods	1.554** (0.0945)				
Adaptation using animal husbandry		2.123** (1.096)			
Adaptation using drought resistant crops			1.970*** (0.0127)		
Adaptation using planting according to rainfall				1.860 (1.456)	
Adaptation through gardening					1.201*** (0.0511)
Constant	1.772** (0.0851)	1.816*** (0.0347)	1.943* (0.0994)	1.578* (0.0990)	1.445** (0.0707)
Obs	300	300	300	300	300

Note: $*p<0.1$; $**p<0.05$; $***p<0.01$. The standard errors are shown in parentheses.
Source: Field Survey, 2020. Values are based on the authors' calculations using binary logistic regression.

Table 4. Effects of climate change adaptation of soyabean cultivation on the livelihoods of small-scale farmers: (2) farmers' incomes improved due to soyabean cultivation, binary logit regression results.

	OR	*OR*	*OR*	*OR*	*OR*
Gender (male)	1.641 (1.555)	1.980 (1.834)	2.112 (2.097)	1.477 (1.399)	1.496 (1.205)
Primary education level and above	1.211** (0.0475)	1.116** (0.0512)	1.127* (0.0864)	1.168* (0.0934)	1.115*** (0.0366)
Years of planting soyabean– squared	1.901* (0.101)	1.234*** (0.0442)	1.783* (0.0641)	1.056** (0.0109)	1.847* (0.0536)
Owns land for farming soyabean (yes)	2.224** (1.097)	2.012*** (1.025)	1.335* (0.0887)	1.099** (0.0776)	2.488** (1.011)
Adaptation using conservation farming methods	2.220* (1.867)				
Adaptation using animal husbandry		1.700** (0.0469)			
Adaptation using drought resistant crops			1.033** (0.0860)		
Adaptation using planting according to rainfall				0.7830 (0.4577)	
Adaptation through gardening					2.458** (1.361)
Constant	1.364*** (0.0105)	1.099** (0.0534)	1.966* (0.0894)	1.097* (0.0994)	1.778** (0.0686)
Obs	300	300	300	300	300

Note: *$p<0.1$; **$p<0.05$; ***$p<0.01$. The standard errors are shown in parentheses.
Source: Field Survey, 2020. Values are based on the authors' calculations using binary logistic regression.

instance, in the first scenario, the odds for income from soyabean increased by 1.211 for respondents who were of primary and above level education compared to those who had not attended any school. When the years of planting soyabean were squared, the results showed that this increased the odds of income by 1.234 at $p<0.05$ in the second scenario. Owning land has been found to increase the odds of increased incomes by 2.224 than if one did not own land in the first scenario at $p<0.05$. The adoption of conservation farming increased the odds of income by 2.220 at $p<0.1$. Adaptation using animal husbandry and gardening increased the odds of income by 1.700 and 2.458, respectively. Planting according to rainfall onset as an adaptive strategy does not impact the odds of income. Finally, without the influence of all the variables discussed, the odds of income increases by 1.364 at $p<0.01$. Therefore, climate change adaptation strategies increase the odds of increasing farmers' incomes, except for planting, according to rainfall onset. As such, the null hypothesis (climate change adaptability has a negative effect on livelihoods when livelihood is measured by the income levels of small-scale farmers) is rejected (Table 5).

The binary logistic regression results for farmers re-investing in livestock production to increase their adaptation to climate change and improve their livelihoods are shown above. Using the decision rule of $p<0.05$, in the first scenario, gender, years of planting soyabean, and adaptation using conservation farming did not statistically increase re-investing in livestock production. This is because these have *t*-tests significant only at $p<0.1$ with coefficients 2.215, 1.555, and 2.011, respectively. On the other hand, primary education and above and land ownership have statistically significant *t*-tests of 1.311 and 2.367 at $p<0.05$. Adaptation using drought-resistant crops increases re-investment in livestock by 2.807 at $p<0.05$. Adaptation using conservation farming, animal husbandry, planting according to rainfall onset, and gardening did not statistically increase livestock re-investment at $p<0.05$. The coefficients are 2.011, 2.807, 0.8633, and 2.458, respectively. Therefore, climate change adaptation strategies increase farmers' capacity to re-invest in livestock production, except for planting, according to rainfall onset. As such, the null hypothesis (climate change adaptability has a negative effect on livelihoods when livelihood is measured by reinvestment in livestock) is rejected. As such, the null hypothesis is that climate change adaptation of soybean cultivation has negatively affected farmers' livelihoods.

There are challenges and opportunities for small-scale farmers to limit the role and importance of soybean cultivation. The analysis shows that there are opportunities related to increasing demand for soyabean, which have translated to better prices than traditional crops such as maize. Farmers exploit the good climatic conditions and cheap access to seeds and fertilizers through state subsidies. This has been shaped by land availability and driven by land use expansion.[1] However, there still remain challenges of access to inputs (seed and fertilizer), seen as driving inequalities between men and women – a potentially key research area. Although prices are

Table 5. Effects of climate change adaptation of soyabean cultivation on the livelihoods of small-scale farmers: (3) farmers' capacity to re-invest in livestock production improved, binary logit regression results.

	OR	*OR*	*OR*	*OR*	*OR*
Gender (male)	2.215 (2.055)	1.966 (1.830)	1.751 (1.560)	2.802 (2.698)	2.113 (2.029)
Primary education level and above	1.311** (0.065)	1.375** (0.0692)	1.427* (0.0746)	1.248* (0.0883)	1.318** (0.0656)
Years of planting soyabean – squared	1.555* (0.0997)	1.945* (0.0969)	1.096*** (0.0117)	1.256* (0.0744)	1.476* (0.0558)
Owns land for farming soyabean (yes)	2.367*** (1.009)	2.872** (1.137)	2.369* (1.945)	1.427** (0.0667)	2.678* (1.997)
Adaptation using conservation farming methods	(2.011)* (1.998)				
Adaptation using animal husbandry		1.947* (0.0991)			
Adaptation using drought resistant crops			2.807** (1.034)		
Adaptation using planting according to rainfall				0.8633 (0.6527)	
Adaptation through gardening					2.458* (1.661)
Constant	1.975** (0.0564)	1.753** (0.0647)	1.888** (0.0742)	1.068*** (0.0425)	1.144* (0.0960)
Obs	300	300	300	300	300

Note: $*p < 0.1$; $**p < 0.05$; $***p < 0.01$. The standard errors are shown in parentheses.
Source: Field Survey, 2020. Values are based on the authors' calculations using binary logistic regression.

comparably better for soyabean than maize, farmers reported still facing market exploitation by the so-called Briefcase Buyers, (private buyers who move door to door in rural areas to purchase soyabean) who reportedly manipulate scale calibrations. There are challenges associated with agricultural machinery, storage facilities, and access to chemical inputs. This includes processing and transportation problems.

5. Discussion: soyabean expansion and wider implications

Currently, smallholder farmers are increasingly becoming integrated into the soybean value chain, driven by a national policy context and market dynamics. State and agribusiness actors have led to the expansion of soyabean over the past decade. For the latter, soybean is largely defined by the value and usefulness of their co-products (Siamabele, 2021). These elements are underpinned by political interests that shape production, processes, and trade dynamics (Manda et al., 2019). Agribusiness expansion provides the necessary market dynamic for soyabean and land use expansion among rural producers, including the possibility of border trading. The cultivation of soyabean under the current climate variability offers many opportunities for small-scale farmers, as it is a drought-resistant crop. In addition, soyabean have many multiplicity effects, which make the crop more economically viable than traditional crops such as maize (Siamabele, 2019).

One of the opportunities realized from soyabean is the crop's capacity to enhance soil fertility (agronomic impacts), which might reduce the costs of acquiring fertilizer for farmers (Mapfumo et al., 2005). There are opportunities for intercropping and crop rotation, limiting intra-household land use conflicts. This flexibility is particularly advantageous for women who traditionally struggle with land access, thus enabling new insights (Manda, 2022).

Furthermore, improving small-scale farmers' productivity directly improves rural households' food security. The study showed that the majority of farmers in soya cultivation were able to improve their food utilization, both physically and economically. A clear division of labour is emerging, where cultivated maize is reserved for household consumption and soyabean are used both as a source of income and food. Soyabean have enabled farmers to access diverse commodities, pointing to nutritional benefits and welfare. Soyabean cultivation at the household level affects farmers' income distribution, intra-household gender relations, allocation and control of resources, material welfare, and human capital development (Glycine max, 2012). At the community level, the adoption of soybean cultivation has improved and changed farmers' attitudes and values, labor, market development, social equity, trade innovativeness, and the potential sustainability of their agricultural activities (Delgado, 1999). The cultivation of soyabean as an adaptation to climate change offers more opportunities for vulnerable rural farmers. However, to be sustainable, support from state and non-state actors is crucial.

There are wider political and economic implications for the expansion of the soyabean. Factors still limit the role, importance, and potential of soybean production across rural livelihoods. The results also showed that for some of the respondents, access to a sufficient amount of land remains a problem (e.g. women and youth). However, for many, the problem is the lack of access to agro-capital to work on land (McKay & Colque, 2016). Existing literature shows that investments and interest in soyabean go well beyond the farm (land). These elements are linked to a large 'soya complex' which includes genetically modified seeds, chemical inputs, agricultural machinery, storage facilities, processing, transportation and the financialization of the agri-food system (Isakson, 2014; McKay & Colque, 2016). This organization raises questions about fairness and justice issues at the lower nodes of the soyabean value chain, enabling further research. Similar to the experiences in Bolivia, it is not clear whether the role and importance of foreign and large-scale capital will continue to expand and the possibility of productive exclusion for Zambian small-scale farmers (McKay & Colque, 2016). As with Oliveira and Schneider (2016), our study points to possible emerging issues related to class formation and reproduction, including the role of the state in agri-industrialization. There are political and environmental implications for soybean production at different scales. Fortunately, these have been framed as solutions to the convergence of multiple crises, including climate, energy, and food. Embedded here are sustainability narratives, and the problem lies here. Thus, we propose these areas for future research.

6. Conclusion

This study assessed the effects of climate change adaptation in soybean cultivation on the livelihoods of small-scale farmers. It focuses on how soyabean adoption shapes rural food security levels, incomes, and prospects for expanding livelihood portfolios, including asset acquisition. This study showed that with prevailing climate change challenges, soyabean adoption presents more opportunities for rural households than traditional crops. The adoption of soyabean cultivation by small-scale farmers enhances their livelihoods owing to its multiplicity effect and the readily available and competitive market. Through improved income levels, farmers are able to improve food access and utilization, both physically and economically. This situation has been evidenced by the binary logit regression model showing that the cultivation of soyabean increases the probability of improved rural livelihoods of small-scale farmers. Thus, the results permit the rejection of the null hypothesis while accepting the alternative hypothesis. We conclude that the adaptation of soybean cultivation must be supported by all involved stakeholders because of its potential to enhance farmers' rural livelihoods. The results showed that the cultivation of soyabean is much more favorable than that of traditional crops such as maize, but does not represent a significant sustainable transition for livelihoods. This study raises the need for development actors, including the government, to strengthen input supply and market opportunities for farmers to strengthen market links. This should be followed by capacity building, such as in the value addition, processing, and nutrition dimensions of soybean expansion.

Note

1. The drop in maize output in 2021/2022 has been alluded to land-use changes driven by soyabean production, though productivity still remains relatively low.

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Ethical approval

The authors acknowledged and cited sources in the reference section and ethical approval number of Ref No. HSSREC-2020-Sep-006 obtained from University of Zambia. Informed consent was written and respondents had to sign in consent before the interview.

Author contributions

The listed authors (Brivery Siamabele and Simon Manda) all contributed in the development and successful completion of this manuscript. Brivery Siamabele and Simon Manda were involved in the conception and design, or analysis and interpretation of the data; the drafting of the paper, revising it critically for intellectual content; and the final approval of the version to be published; and all authors agree to be accountable for all aspects of the work.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

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