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# APSTRACT

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# THE ROLE OF DIGITALIZATION IN SUSTAINABLE AGRICULTURE

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**Abstract:** *ICT, digital and smart tools are an integral part of a competitive agriculture in the 21st century. The world's population is growing, which also means that demand for food will increase, so there is a need to increase agricultural productivity (increasing output/input factor efficiency), for which technological innovation is essential. An important aspect is that some factors of production in agriculture are limited (land, water, etc.), so a fundamental issue for farmers in agriculture is how to carry out their agricultural activities in a sustainable and cost-effective way. Innovative and modern solutions are needed to increase productivity in agriculture in a sustainable way. Digitalisation, of which data and the information derived from data are an integral part, is the basis for these innovative solutions. Technological progress and digitalisation are making a major contribution to the emergence of sustainable agriculture.*

*The aim of the present study is to briefly describe the development and milestones of agriculture, based on a literature review, and to highlight the importance of agricultural digitisation, especially from the perspective of sustainable agriculture.*

**Keywords:** *Sustainable agriculture, Digitalisation, Innovation, ICT tools, Smart farm*  
(JEL code: Q1, Q2)

## INTRODUCTION

The three basic questions of economics: what? for whom? how to produce? In the latter case, in the concept of how to produce, the input factors used play a decisive role, which are incorporated into the price of the products produced and processed, and thus represent costs for the farmer (PUPOS et al. 2021). For farmers, as for all other economic units, the important goal is to achieve the economic optimum and increase profitability, and for this purpose the use of ICT (Information Communication Technology), IoT, smart, precision tools and technologies is essential in day-to-day activities. Nowadays, ICT tools have become an integral part of our lives, and are therefore the pillars of modern, state-of-the-art agriculture (THAPA et al. 2020). By using ICT tools, farmers can obtain up-to-date data and information on weather, crop conditions, new and innovative technologies, input prices, and input use (PUPOS et al. 2021).

The concept of precision agriculture, which includes ISO-BUS connectivity and GIS (Geographical Information System) based soil monitoring, crop condition assessment and crop mapping, is inevitable in this field. Industry 4.0 has significantly expanded the concept of precision agriculture, for example, the aforementioned mapping can be done by drones, which provides much more accurate maps with higher resolution (PAN-DA et. al, 2018). The monitoring of crop status: weed control,

identification of diseases, pests and interventions can also be done faster, efficiently and with optimal input use through the use of ICT and IoT (Internet of Things), thus reducing the environmental impact and the use of pesticides (KOUNTIOS et al. 2023).

Digitalization in agriculture is the process of using data-rich software, hardware, and services to increase productivity and efficiency while reducing costs, labor requirements, environmental impact, and agricultural externalities (TANKOSIC et al. 2024; GETAHUN et al. 2024).

In fact, digital solutions will make agriculture more sustainable, more efficient in production and the digitalisation trend in agriculture will have a positive impact on the social, economic and environmental dimension of rural areas (PÉLUCHA et al. 2023). In the European Union, the digitalisation of agriculture is an important and topical issue, through which global agricultural problems such as the safe and adequate feeding of the world, the conscious and optimal use of scarce input resources, and the reduction of environmental pressures can be mitigated (EUROPEAN COMMISSION, 2021).

## MATERIALS AND METHODS

The study primarily used an analytical approach to achieve its research objectives, focusing on the interaction between

digitalization and sustainable agriculture. The methodology of the study is based on a comprehensive analytical review.

During the secondary information gathering we examined the importance of digitisation in agriculture by using international and national scientific publications, textbooks and studies. In our literature search, we used the following sources: Eurostat, FAO, EMIS, World Bank, Google Scholar, Research Gate, Web of Science, Science Direct. We used the following keywords and their combinations in the search:

- Digitalisation of agriculture
- ICT tools in agriculture
- ICT for agriculture, e.g. in the field of digital agriculture
- Sustainable crop production
- Precision farming
- Smart farming
- Green Deal

In addition to the keywords used above, we also considered it important to use only relevant and relatively recent articles and studies. The literature was selected by relevance and year of publication, focusing on the use of current and relevant literature.

## RESULTS AND DISCUSSIONS

### Digital ICT tools in agriculture and the concept of the smart farm

The development of agriculture has taken place and is taking place in different parts of the world with different intensities and at different rates. Table 1 summarizes the major milestones and dates of emergence of digitalization of agriculture (SZŐKE – KOVÁCS, 2020; RAJ et al. 2021). The table includes the first foundational step for each technology, its development where appropriate, but dating the introduction of a technology is not always straightforward, as it is not always clear when a technology moves from scientific discovery to prototype, beta testing and then to the standardised commercial product category (LOWENBERG – DEBOER, 2022).

Looking at the history of agricultural development, agricultural production has increased through the use of new technologies, irrigation, fertilisers and pesticides. In Germany, in the 1920s, a farmer harvested an average of 1.85 tonnes of wheat per hectare; today, wheat yields average 7.6 tonnes per hectare (BALL et al. 2001, RAJ et al, 2021). In America, in the 1930s, one farmer produced enough agricultural produce for four people, 40 years later this ratio had risen to 73 people, and thanks to innovation, technology and engineering, by 2010 a farmer was producing and providing food for 150 people a year and 164 in 2016 (STATISTA, 2022). At the same time, agriculture will have to provide 70% more food for a growing population by 2050 using fewer inputs (water, pesticides, land) (MATTHIEU et al. 2018).

In the 21st century, the use of ICT tools plays a crucial role in all economic sectors, enabling more efficient production and operations. ICT tools enable (agricultural) business managers to make decisions, produce and manage their businesses faster and more efficiently. Up-to-date information

and data are essential for both production and sales, and help to improve efficiency in production, while in sales the lack of information can lead to a competitive disadvantage (CSÓTÓ, 2013). According to Csótó, the concept of ICT includes software (applications, decision-support programs), hardware (smartphones, computers, laptops, tablets, etc.) and the Internet (information source) (CSÓTÓ, 2013; BALINT et al. 2025). Nowadays, digital literacy is an expected competence, although the lack of digital literacy is a problem in the agricultural sector (PÉNTEK et al. 2025).

**Table 1. Milestones in the process of digitalisation of agriculture**

Year	Technology, development activity	Company, organisation	Country
1974	Electronic identification of animals	Montana State University	USA
1983	Use of GPS	USA Yamaha	USA Japan
1987	Use of drones	SoilTeq	USA
1992	(spraying, fertilizer application)	Lely	Netherlands
1997	Computer controlled variable rate application (VRT) of fertilizer	Beeline Yara	Australia Norway
2006	Milking robot	Trimble	USA
2009	GNNS (Global Navigation Satellite System) controlled agricultural machinery	Ag Leader	USA
2011	N-sensor (nitrogen fertilizer signal(s))	Ecorobotix Naïo Technologies	Switzerland France
2013	Automated sprayer section control	Class	Germany
2017	Row closing	Harper Adams University	England
2022	Planting robot	John Deere	USA

*Source: own edits (FAO, 2022, based on LOWENBERG-DEBOER, 2022)*






Looking at the history of the development of agriculture, digitalisation is a major milestone in the agricultural sector. Technologies that were previously considered traditional are

being replaced by new, more efficient, innovative, digital technologies, smart solutions. Today's modern and competitive agriculture is inconceivable without the use of digital tools and farm management software, smart solutions. Up-to-date, up-to-date data play an important role in informed and efficient decision-making. Mobile applications and farm management software provide farmers with up-to-date data and information on crop conditions, market prices (input and product prices), weather conditions, which help farmers in their daily and all kinds of decision making. Based on the above, the digitalisation of agriculture creates the opportunity for the farming processes, management to be based on data-driven decision making and to be an integral part of the smart farm. Table 2 shows the components of a data-driven

smart farm. The first most important element is the crop, which is actually the beginning and the end of the farm management cycle, in the initial concept by sowing and planting and in the final concept by harvesting. Monitoring the status of the crop from sowing, planting to harvesting is an integral part of the smart, data-driven farm. Management or treatment zones are homogeneous territorial units within a plot, through which interventions can be tailored to reduce the use of inputs (pesticides, herbicides, etc.), improve yields, reduce environmental stress, and in fact form the basis of precision farming (SAIZ et al. 2020; THAKKAR et al. 2024).

The sub-categories of the platform are sensors and remote sensing, which can be used to collect data on crops, soil or, where appropriate, weather. Platforms can be placed

**Table 2. Components of the data-driven economy**

Category	Subcategory	Category	Subcategory
	<b>Culture</b>		Precision farming and the smart farm Management zones
	<b>Platform</b>		Remote sensing (satellite, drones) Ground sensors
	<b>Data</b>		Big Data Internet of Things (IoT) Mapping Information systems (GIS, FMIS)
	<b>Decision</b>		Artificial Intelligence (AI) Decision Support Systems (DSS)
	<b>Intervention</b>		Variable Rate Technology (VRT/VRA)

Source: based on own editing (SAIZ et al. 2020)

on agricultural vehicles (tractor, combine, etc.) or fixed to the ground within the plot, such as local weather stations (TRENDOV et al. 2019). Near-ground sensors (proximal sensors) provide signals from the ground to the plot by placing the sensor in contact with the ground or within 2 m of the ground. Remote sensing has been a key element in the development of the smart economy, whereby useful information about the plot (crop, land) has become available via satellites. The satellites providing agricultural information are Landsat in the US, Sentinel in Europe, RapidEye constellation, GeoEye. There are numerous possibilities for farmers

to collect satellite data (KIANI et al. 2022). A new concept and technology in this respect is the use of thermal imaging cameras. One of the most important components of a smart farm is data. The fundamental difference between a conventional farm and a smart farm, apart from the level of mechanisation, is that the latter allows farmers to collect up-to-date information on a given plot of land or crop. One of the tools for presenting the collected data in a consistent form is the map (vegetation index map, weed map, yield map, etc.), which provides the basis for decision-making by farmers. The maps enable farmers to delimit management and

intervention zones. The next step after data consolidation is the interpretation of the data, which informs the decision on how and why to intervene. Data management software helps farmers to make decisions, but also allows them to monitor what is happening on the farm (LAKATOS, 2019; KIANI et al. 2022; SAIZ et al. 2020).

Nowadays, the applications of drones and robots are becoming more and more diverse in all industries, including agriculture. Drones have been used for precision spraying in Japan since the 1980s. Spraying and fertilisation using drones offers many advantages for farmers: no trampling damage, no fuel costs, high area coverage (10-17 ha per hour), optimisation of crop water requirements, pesticide savings of up to 30% (TÓTH, 2021). Drones and sensing technology are an integral part of Agriculture 4.0 and the 5th pillar of agriculture is artificial intelligence and robotisation, while robotisation is also closely linked and interacts with artificial intelligence, information and communication technology and sensor technology. Technological changes in industry also have an impact on the technologies used in agriculture (BÁRTFAI et al. 2018). Digital technologies have an important role to play in the development and operation of an efficient and sustainable agriculture. One of the key components of current technologies is the acquisition of up-to-date data and information using sensor technology and multispectral cameras, and the processing of the data, through which cost reductions and output increases can be realized (ARZA -GARCÍA & BURGESS 2023; BHARDWAJ et al. 2025). Digital technologies are now widely available in all EU Member States, but there is a huge gap in the

way these technologies are used. There are several reasons for this, the first is the capital required for the initial investment, the second is the digital competences and skills needed to use these technologies and in many cases farmers perceive them as complex to use and apply, which discourages them from adopting new and innovative technologies (European Commission, 2019; PATAKI et al. 2021).

### Digitalisation and sustainable agriculture

Mention of the European Green Deal agreement is essential in the context of agricultural sustainability, whose strategic goal is to achieve a modern, sustainable, competitive agriculture. Agricultural stakeholders are involved in the Farm to Fork strategy through the following themes:

- developing a sustainable food chain with a focus on food safety
- biodiversity, preserving plant and animal diversity
- maintaining healthy forests and increasing forest cover
- contributing to the Zero Pollution Action Plan by preserving and conserving natural resources (water, air, soil)

Precision sensing, IoT and drone platforms form the operational backbone of digital agriculture by enabling high-resolution, spatially explicit monitoring and variable-rate interventions. Digitalization—sensors, IoT, AI/ML, remote sensing, blockchain, and digital twins—enables more efficient, monitored, and data-driven farming (MILLER et al. 2025; GETAHUN et al. 2024; DELANEY et al. 2025).

Digital agriculture technologies and their application are linked to the Green Deal through Farm to Fork in several ways, such as positive environmental impacts: opti-

**Table 3. Summary table use of ICT tools, digital tools and sustainability benefits**

Technology	Functions	Sustainability benefits	Sources
IoT field sensors	Continuous microclimate/soil monitoring	Enables optimized irrigation and inputs	(GETAHUN et al. 2024)
UAV remote sensing	High-res crop health mapping	Early stress/disease detection; targeted interventions	(ZHANG, et al. 2019, KHAN et al. 2024)
NIR point sensors	Chemical composition at standoff points	Lower-cost spectral monitoring	(DELANEY et al. 2025)
GPS/VRT machinery	Variable-rate seeding/fertiliser/pesticide application	Input reductions and yield efficiency	(GETAHUN et al. 2024)
Soilless IoT systems	Controlled-environment monitoring (hydro/aero/vertical)	Year-round high-efficiency production	(DUTTA et al. 2025)

Source: own editing based on GETAHUN et al. 2024; ZHANG, et al. 2019; KHAN et al. 2024; DUTTA et al. 2025)

mised chemical application, optimised seeding, irrigation, soil conservation, drone spraying, while digitalisation also contributes to increased productivity. The latter also means that self-cost reductions can be realised, which is a pillar of competitiveness. It also helps in yield estimation, crop harvesting and traceability, which also contribute to safe food production. Thus, based on the above, the digitalisation

of agriculture also contributes to social, environmental and economic sustainability (TAKÁCSNÉ, 2022; TAKÁCSNÉ, 2020; TUREK, 2013).

Climate-smart farming is about putting new, state-of-the-art technologies into practice, based on the pillars of improving farmers' income and living standards, sustainably increasing agricultural productivity, adapting to climate

change and reducing greenhouse gas emissions (TAKÁCSNÉ, 2022).

**The benefits of digitization**

***Improving productivity and efficiency***

- Digital technologies such as sensors, robotics, and data-driven tools are revolutionizing European agriculture by enabling precise decision-making. This leads to increased productivity and more efficient use of resources.

Time savings and process simplification

- Digital tools help simplify operations and save time for farmers.

***Sustainability and resource management***

- Digital technologies promote sustainability and reduce resource consumption. Digital platforms contribute to reducing chemicals and improving traceability, which increases food safety.

***Innovation, attracting younger generations***

- Digitalization supports innovative business models and the use of digital, innovative technologies will make agriculture more attractive to the younger generation. (ILIOPOULOS et al. 2025)

**Barriers of digitization**

***Costs***

- High costs of digital solutions, farmers often cite the significant costs associated with digital adoption as a major barrier.

- The disadvantaged positions of small farms

***Lack of knowledge and infrastructure deficiencies***

- Lack of digital skills needed to use new digital tech-

nologies

- Limited internet connectivity, particularly in rural areas

***Trust issues and data and data privacy concerns***

- Issues related to data ownership and control pose significant barriers (ILIOPOULOS et al. 2025)

The CAP aims to make European agriculture more sustainable while ensuring a fair standard of living for EU farmers. It ensures the competitiveness and sustainability of agriculture through a combination of direct payments, market measures and rural development measures. EIP-AGRI is an acronym for the European Innovation Partnership for Agricultural Productivity and Sustainability, launched in 2012 to deliver the Europe 2020 strategy for smart, sustainable and inclusive growth (European Commission, 2023). Table 4 shows the H2020 projects related to digital agriculture and their brief description (ILIOPOULOS et al. 2025, VORONKOVA et al., 2025).

Horizon 2020 is the EU's biggest research and innovation programme. Through the Framework Programme, more than €200 million has been earmarked for research and innovation (R&I), for the introduction of digital technologies in the agricultural sector. These funds are aimed at the development and deployment of digital technologies that enable precision farming, sustainable agriculture and more efficient food production (European Commission, 2023; HORVÁTH et al. 2017).

The digitalisation of agriculture and sustainability are strategic global, European and national policy objectives. Some examples are the European F2F Strategy, the German Agricultural Field Strategy 2035 and the German Sustainability Strategy. The F2F strategy also emphasises the importance of digitalisation by optimising the use of agricultural inputs, which contributes to reducing environmental

**Table 4. H2020 projects related to Digital Agriculture**

Title	Link	Topic	Link
IoF2020		The project aims to accelerate the use of IoT technology in agriculture and food to improve food safety, increase productivity and strengthen European competitiveness.	<a href="https://www.iof2020.eu/">https://www.iof2020.eu/</a>
Atlas		The project aims to address the lack of data interoperability (the ability for different systems, devices or software to work together) in agriculture by creating an open platform that provides hardware and software interoperability using sensor data.	<a href="https://www.atlas-h2020.eu/objectives/">https://www.atlas-h2020.eu/objectives/</a>

Title Link	Topic	Link
<b>Demeter</b>	The project aims to deploy farmer-centric, interoperable smart farming platforms in 18 countries through 20 pilot projects, involving 60 partners, 25 deployment sites and 6000 farmers. It will optimise multi-farm data analytics and provide an open and interoperable data integration model. It also aims to support sustainable farming and food production systems, ensure safe food and create new business opportunities for the farm and the wider agri-food economy.	<a href="https://h2020-demeter.eu/">https://h2020-demeter.eu/</a>
<b>SmartAgriHubs</b>	The project aims to accelerate the digital transformation of the European agri-food sector by building a network of digital innovation hubs to boost the uptake of digital solutions by the agricultural sector. It includes 28 flagship innovation experiments that will showcase digital innovations in agriculture and improve the maturity of digital innovation services to ensure that digital innovations are rolled out across Europe and widely adopted by European farmers.	<a href="https://www.smartagrihubs.eu/">https://www.smartagrihubs.eu/</a>
<b>agROBOfood</b>	It aims to accelerate the digital transformation of the European agri-food sector through the introduction of robotic technologies. Its main objective is to create a sustainable network of digital innovation hubs that will boost the uptake of robotics solutions by the agri-food sector with the aim of maximising the return on European investment and transforming the sector.	<a href="https://agrobofood.eu/">https://agrobofood.eu/</a>
<b>Romi</b>	Its aim is to develop a platform for leaders and innovators in agri-technology robotics in Europe. The network aims to reduce and overcome the barriers that agri-food companies face and to help them access the latest robotic agricultural solutions.	<a href="https://agrobofood.eu/">https://agrobofood.eu/</a>
<b>Pantheon</b>	Its aim is to develop a new method for monitoring plant health in order to detect plant diseases and to take corrective action. The main objective is to develop approaches for continuous monitoring of plant health with unprecedented precision.	<a href="https://pantheonproject.eu/">https://pantheonproject.eu/</a>

Source: own editing based on GETAHUN et al. 2024; ZHANG, et al. 2019; KHAN et al. 2024; DUTTA et al. 2025)

pressures, helps farmers to produce more efficiently, and informs consumers about food and how food is produced. In Germany, agri-digitalisation is a national priority and one of the 12 objectives of the 2035 agricultural field strategy (JOSEPH et al. 2022).

Biotechnology could be a future research topic in the study of digitization and sustainable agriculture. Digital agriculture and biotechnology are revolutionizing modern farming by combining cutting-edge technologies with biological innovations to promote sustainable development. Artificial intelligence (AI), the Internet of Things (IoT), and data ana-

lytics will also play an important role in this regard, these tools optimize resource utilization and improve productivity with real-time monitoring (NATH & TRIPURA, 2025).

## CONCLUSION

The digitalisation of agriculture is helping to ensure a sustainable food supply in many ways. Various policies and strategies, such as the F2F strategy, the German Agricultural Field Strategy 2035 and the German Sustainability Strategy, and various research and development projects within the

European Union, H2020, are helping to foster agricultural digitisation.

ICT tools, farm management software, IoT, precision agriculture technologies (agricultural drones, sensors), artificial intelligence contribute to the sustainability of agriculture and optimise farmers' costs, as well as greatly improve production efficiency. Digital technologies can provide consumers with more detailed and transparent information on the conditions of production and nutritional content of food, and farmers with information and better understanding of consumer preferences and trends. This new dynamic between consumers and producers could also be crucial for achieving sustainability goals.

The adoption of digital agriculture and the use of its tools and technologies are hampered by a number of factors, such as high investment costs, lack of expertise, lack of knowledge, lack of trust on the part of farmers, farm structure (small farms), lack of uniform legislation on drone spraying. Developing an appropriate strategy that reflects the above-mentioned problems and includes solutions to these problems could be one of the solutions. Solutions could include financial support for farmers, the provision of advice and training, and the development of uniform drone legislation within the EU.

The European Union can help in several ways to promote the adoption of digital, sustainable agricultural practices. The combination of public subsidies, environmental policies, and public investment in R&D are effective tools for increasing both agricultural productivity and sustainability, which has a significant impact on future policy development.

Based on the literature research, it can be stated that digitalization, new technologies and IoT contribute greatly to the development of sustainable agriculture, but the process of its completion is a multi-stakeholder process, in which not only farmers have to play a role, but also Member States, agricultural policy makers, farmers' organizations and educational institutions.

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# THE PLACE OF AGRICULTURE IN YOUNG PEOPLE'S LIVELIHOOD ASPIRATIONS

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**Abstract:** *This study examines the dynamics of youth aspirations and livelihood choices in agriculture. It focuses on how combined socio-economic, individual, and household characteristics in Bure Zuria Woreda, a rural community in West Gojjam, Northwest Ethiopia, influence youths' livelihood decision-making. In the study, we employed a sample survey, focus group discussions (FGD), in-depth interviews (IDI), and key informant interviews (KII). Using both individual and household-level data, we conducted a multi-stage analysis, specifically descriptive statistics and a multinomial logistic regression model, along with thematic analysis for qualitative data. We contextualize young people in agriculture by exploring how changing access to land, educational levels, gender, the conditions of agriculture, the economic viability of the agricultural sector, and the perceptions of the status of agriculture influence livelihood decision-making. The result shows that youth livelihood choices and aspirations in agriculture affected by socio-demographic factors at the individual, household, and societal levels. Farming land size, educational level, gender, the conditions of agriculture in the locality, the economic viability of agriculture, and nearby family career preferences were found among the factors that determine the aspiration and livelihood of young people in agriculture. The study also found that the status associated with agriculture was not significant in affecting the livelihood choices of youth. The results underscore the importance of understanding the dynamics of young people's individual and household characteristics and socio-economic conditions for sustainable livelihoods. Therefore, targeted interventions are essential to improve youth's sustainable livelihood in agriculture.*

**Keywords:** Youth aspiration, Livelihood choice, Socio-economic factors, Agriculture  
(JEL code: Q01 )

## INTRODUCTION

Ethiopia, the most populous nations in sub-Saharan Africa with an estimated population of nearly 123 million, has an economy primarily driven by agriculture (UNDP, 2022b). According to the Ethiopian Labor Force Survey of 2021, out of the total youth population of 26 million, approximately 73.6% reside in rural areas, highlighting the significant rural demographic that predominantly depends on agriculture for livelihood and economic activity. Schmidt and Woldeyes (2019) reported that only 23% of Ethiopia's economically active population works mainly in the nonagricultural sector, indicating that the vast majority, including youth, remains engaged in agriculture. This continued reliance underscores the importance of youth participation in agriculture, as their engagement is vital for the sector's future development and holds significant potential for reducing poverty, unemployment, and inequality across Africa (Geza et al., 2022). Engaging youth in agriculture is seen as an important strategy for effective and sustainable food system transformation in developing countries (Babu et al., 2021).

Studies in Ethiopia and many developing countries have shown that rural youth are less interested in agriculture (Bezu & Holden, 2014; Sumberg et al., 2017, 2024). In Ethiopia, Elias et al. (2018) reported that farming is “considered a for those who ‘failed’”, whereas Tadele & Gella (2012) reported that farming is considered “backward, demanding and even demeaning” as a “last resort, and for many not an option at all”. Similarly, Sumberg et al. (2017) in Ghana also reported that young people view farming as a hard job that is unable to be a viable means of livelihood. Studies (Holden & Tilahun, 2021; Tadele & Gella, 2012; Tafere & Woldehanna, 2012) conducted in Ethiopia have noted that individual- and household-level characteristics are strongly linked with the aspirations of rural youth.

Rural households use a variety of tactics to earn the income needed to achieve their livelihood goals (Yobe et al., 2019). In order to achieve their goals, young people can decide to engage in a variety of livelihood strategies, or combinations of these, including farming or non-farming, migration, remittances, wage work, or self-employment (Matita et al., 2022).

Youth farming endeavors are sometimes presented in policy discussions as a “take it or leave it” choice ((LaRue

et al., 2021). Moreover, Moreda (2023) indicated that young people in rural areas are forced to leave in pursuit of alternative means of livelihood due to limited access to land, pulling them away from agricultural livelihoods. At the global level, it has been commonly argued that young people tend to consider agriculture as a non-promising and nonviable means of livelihood.

On the other hand, while youth often aspire to high-status jobs, non-farming jobs but they can adjust their aspirations to attainable livelihoods. While many young people aspire to high-status careers and attaining these goals are often difficult, youth frequently adjust their aspirations based on emerging opportunities and barriers that arise as they navigate through different stages of life reflecting a dynamic and non-linear process of career development (Marzi, 2022). The person's traditional or primary source of income may eventually be replaced by alternative livelihood strategy and, it may lead to the long-term coexistence of alternative and conventional livelihoods and the context and viability of a person's available livelihood options determine the final choice of livelihoods (Ocloo et al., 2025).

A household's combination of income generating activities, which can be determined by changing assets and circumstances, is known as livelihood strategy (Ellis, 2000). It can be described as the pull and push factors that influence the choice of livelihood decisions (Bezu et al., 2014). The decisions of young people livelihood can be reinforced by dominant narratives of the family, belonging, prestige, and material possessions (Korzenevica, 2021). Although socio-economic, institutional, and community factors are widely recognized as major influences on livelihood strategies in the literature (Kangondo et al., 2023; Rahman & Akter, 2014), there is also a common consensus that livelihood choices and their determinants are context-specific and can vary across different local settings (Peralta, 2022).

In spite of recent development in livelihood studies (Bezu & Holden, 2014) in developing countries and a witnessed growing interest in the study of youth and their livelihood strategies (Kangondo et al., 2023), there is limited literature on the determinants of their livelihood choice and aspirations, especially in the context of rural youth. Policy-making can be enhanced by an awareness of the variables influencing the livelihood options used by rural households (Yobe et al., 2019). Thus, a more nuanced understanding of young people's interest in farming is essential to poverty alleviation-oriented development strategies (Babu et al., 2021).

Thus, it is worthwhile to study the determinants of youth livelihood strategies and aspirations in agriculture to understand the social dynamics of the aspirations of youth in the agricultural sector.

Moreover, the study of youth and their aspirations is limited by conceptual constraints. We have conceptualized youth and aspirations within the context of agricultural livelihoods. In this study, while acknowledging the contestation surrounding the definition of youth, the researchers view youth as rural households and individuals who engage in subsistence agriculture on small plots of land and relying heavily on family labor, with ages ranging from 15-35 years. The study use age

and social category, adopting the Ethiopian age range for the lower limit and the African Union age range for the upper limit. Moreover, aspiration is defined as the desire to engage in agriculture or other means of livelihood. Our conceptualization of aspirations emphasizes their socially constructed nature, creating a fertile ground for understanding the social dynamics influencing youth livelihood choices within the context of agricultural employment. 'Aspirations' are embedded in the material and social context and are made up of young people's embodied and emotional longing (Moensted, 2021) which can guide the livelihood strategies of youth in agriculture. In order to achieve their goals, young people can decide to engage in a variety of livelihood strategies, or combinations of these, including farming or non-farming, migration, remittances, wage work, or self-employment (Matita et al., 2022).

Thus, this study focuses on the factors that influence young people's paths into and out of agriculture, as well as how they view agriculture and rural living as a means of subsistence. It particularly focus on how the combined socio-economic and individual and household characteristics is affecting youths' future-oriented, livelihood decision-making while considering youth are active decision-makers, shaping current and future local food production in Ethiopia, Bure Zuria Woreda, from the perspective of young people sustainable livelihoods

## MATERIALS AND METHODS

### Study Area

The data for this study were collected from Bure Zuria Woreda in the West Gojjam Zone of the Amhara region, Ethiopia. According to the Ethiopian Statistical Service (CSS), the projected total population of Bure Woreda for 2024 is 209,923. In the Woreda about 68% (142,994) living in rural areas and 66,929 in urban areas, highlighting that the majority of the population in this district resides in rural areas where agriculture serves as the primary livelihood (CSS, 2024). The study area is known for its high agricultural potential and a large number of young laborers who participate both directly and indirectly in agricultural activities. According to the 2022 survey by the Woreda Economic and Plan Bureau, 38% of the Bure Woreda population falls between the ages of 14 and 35 years.

The study area is also one of the major agro-industrial zones in Ethiopia, where the Burea industrial zone is located. Furthermore, the area faces significant challenges, including high youth unemployment, with many young people, including graduates, remaining engaged in agriculture for subsistence amid limited job opportunities. As one of Ethiopia's major agro-industrial hubs, Bure Zuria Woreda provides a vital context for examining the socioeconomic factors influencing youth livelihood choices and their aspirations in agriculture, making it an ideal site for understanding the intersection of youth employment, socioeconomic characteristics, and rural development dynamics.

### Study approach and target population

A mixed-methods research design and an explanatory approach were employed. Quantitative and qualitative data were

collected simultaneously during a single visit to the study area. The study focused on two main youth groups: the first includes those working on their own family-based farms, which vary in size and landholding access, ranging from 0.25 acres to 1 hectare, often through renting. The second group consists of youth who graduated from higher educational institutions but did not secure employment outside agriculture; they consider themselves employed and rely on family support or subsistence farming, on either government-accessed farmland or land received as gifts from family members.

**Data Source, Sampling procedure and Data collection methods**

Both primary and secondary sources of the data were gathered. Questionnaires, key informant interviews (KIIs), and focus group discussions (FGDs) were used to collect primary data, while document review was used to gather secondary data. The sample for qualitative data was selected purposively. The KIIs were identified based on their knowledge, experiences, and professional proximity to youth, agriculture, and related development issues.

Interviews were conducted with experts, government officials, and youth representatives involved in youth, employment, labor, and agriculture sectors. FGDs were held with both non-graduate and graduate young farmers to explore their perspectives on their aspirations and factors affecting their aspirations and livelihood choices. Each FGD included 8-10 participants from different youth categories. All FGDs were voice-recorded, with notes taken upon participants' consent. Likewise, IDIs were conducted with all categories of young people to gather detailed insights into their personal experiences and beliefs regarding the issues studied. Interview guides tailored for KIIs, IDIs, and FGDs were developed.

The survey samples were drawn from youth populations, with lists obtained from government offices. Non-graduate farmers were randomly selected from specific kebeles in Bure Woreda, namely Tiyatiya and Shakua, targeting both individuals and households. Graduate youth samples were taken from all kebeles in the district involved in agriculture. Local administrators and extension workers facilitated the identification of participants. Selected individuals were contacted via mobile phone and local focal persons to confirm their availability and willingness to participate. The survey was conducted through self-administered questionnaires after face-to-face contact with respondents. These questionnaires covered socio-demographic details, aspirations in agriculture, livelihood choices, characteristics of agriculture, and the livelihoods within the agricultural sector. When necessary, the researchers used a replacement method to substitute unavailable or unwilling participants.

In determining the sample size for quantitative data, the following sampling formula has employed, with  $p=.50$ ,  $t=1.96$ , and a margin of error of 95% considering the nature of the issue under investigation, and the data is categorical,(Lenth, 2001).

The value of  $t$  equals the chosen alpha level of 0.025 in each tail, which is 1.96. The alpha level of .05 indicates the level of risk that was taken, where the true margin of error

may exceed the acceptable margin of error. Thus, to compute the sample from the population;

$$n = \frac{(t)^2 * p * q * N}{(d)^2(N - 1) + (t)^2 * p * q}$$

$$n = \frac{(1.96)^2 * 0.5 * .05 * 1800}{(0.06)^2(1800 - 1) + (1.96)^2 * 0.5 * .05}$$

$$n = \frac{1728}{7.43} = 232$$

Where  $n$  = number of sample size  
 $N$  = total number of population (1800)  
 $d$  = acceptable margin of error for proportion being estimated = .06 (error decided to accept)

Thus, 232 young people were selected randomly who were drawn from college graduates and young farmers from Bure Zuria woreda.

Likewise, under the principle of data saturation, 12 FGD, 16 IDI with all categories of youth participants, and 16 KII with the representatives and experts of the study area government offices and local community representatives were interviewed.

**Data analysis**

The study employed a sequential mixed-methods approach, combining qualitative and quantitative data for comprehensive analysis and interpretation to ensure convergence of findings. Qualitative data were categorized and analyzed contextually using thematic analysis. The data analysis has involved translation, cleaning, reviewing, organizing the data, coding, classifying into themes, identifying links, and interpretation. While quantitative data obtained from questionnaires, the analysis included both descriptive statistics and inferential statistical tests to draw meaningful conclusions from the data, facilitating a robust understanding of the research questions.

**Model Specification; Analysis of socio-demographic factors on livelihood choices**

For scholars and policymakers alike, categorizing household livelihood choices is crucial (Tran et al., 2020). The literature indicates a significant change in the categorization of livelihood strategies in agriculture. It has been broadly categorizing livelihood activities into farm and non-farm activities. Recently, classification of livelihood activities has extended to specific categories. To comprehend the dynamics of shifts in young people's involvement in various means of livelihood that are typically thought to be accessible to rural residents with farming origins can be categorized as farming through agricultural intensification; livelihood diversification; and out-migration to pursue livelihood opportunities elsewhere (Angelique et al., 2024). Thus, in this paper, we have used a hybrid classification where we broadly group activities as agricultural/farm and non-agricultural/ non-farm and add more

specific activities such as migration and other livelihood strategies in the classification.

Beyond this, when the values of a categorical dependent variable are not sorted, the multinomial logit model can be used. The study in Zambia (Ogunjimi et al., 2023) utilized the model to study factors and actors shaping the aspirations of rural youth. The studies in Ethiopia on livelihood choices, for instance, (Tassie Wegedie, 2018) used the model to analyze determinants of peri-urban households' livelihood strategy choices, and (Alamneh et al., 2023) used it to study the choices of livelihood diversification strategies. This has motivated the researchers to apply the model to estimate the role of socio economic and demographic factors on young people choice of their aspired livelihood strategies and determine the place of agriculture in their livelihood choices.

The data collected through survey were analyzed to understand the socioeconomic and demographic determinants of youth livelihood choices. Agricultural jobs in the locality, nonagricultural jobs, migration in search of alternatives and any other option, are the categories used to estimate a multinomial logit model for the prediction of livelihood probabilities based on various independent variables. The determinants of a young individual's livelihood choice were examined using a multinomial logit model (MLM). Assume that  $(j = 1, 2, 3, 4)$  represents the likelihood that young people will select a particular livelihood. If a youth intended to pursue an agricultural livelihood in the area,  $j = 1$ ; if they intended to pursue a non-agricultural livelihood,  $j = 2$ ; if they intended to migrate in search of an alternative livelihood,  $j = 3$ ; and if they intended to search for other livelihood options,  $j = 4$ . Given a value of  $x_i$  for the explanatory variable,  $P_{ij} (j=k|X_i)$  is the likelihood that person  $i$  belong to category  $j$ ; Taking the  $J$  category as the baseline, the response probabilities are explained as follows:

$$P_{ij} (j = k|X_i) = \frac{\text{Exp}(\beta_k X_i)}{1 + \sum_{j=1}^4 \text{exp}(\beta_k X_i)} = j = 1, 2, 3, 4 \tag{1}$$

The  $i$ , indicates the  $i$ th youth population in the sample and  $\beta_k$  are coefficients to be estimated  $j$  given the independent variables and  $\beta_{(1)}, \beta_2, \dots, \beta_k$  measure percentage changes in youth livelihood options that result from a change in socio-demographic characteristics. Thus, set  $\beta_j$  to zero for one youth livelihood category (say, pursuing agriculture), then the model for each category can be presented as:

$$P_{ij} (j = k|X_i) = \frac{\text{Exp}(\beta_k X_i)}{1 + \sum_{j=1}^4 \text{exp}(\beta_k X_i)} = j = 1, 2, 3, 4 \tag{2}$$

and

$$P_{ij} (j = 1|X_i) = \frac{1}{1 + \sum_{j=1}^4 \text{exp}(\beta_k X_i)}$$

Thus, the following equation (3) was used to predict socio-economic and demographic variables related with young people livelihood choice and the place of agriculture.  $\beta_i$  is the parameter that requires estimation; LandSize represents land size; Edn represents educational level of study participant; Gender represents sex of the youth; MaritalStatus represents the marital status of youth; PCareerPre denotes young people parents career preferences; Agrivability represent economic viability of agriculture; AgriConditions represents the conditions of local agriculture; Liveprestige also represent the status of livelihood in agriculture and  $e_i$  is an error term.

$$P_{ij} (j = k|X_i) = \beta_0 + \beta_1 \text{LandSize} + \beta_2 \text{Edn} + \beta_3 \text{Gender} + \beta_4 \text{MaritalStatus} + \beta_5 \text{PCareerPre} + \beta_6 \text{Agrivability} + \beta_7 \text{AgriConditions} + \beta_8 \text{Liveprestige} + e_i \tag{3}$$

Pursuing agriculture, or category 2, was selected as the reference category for this study. Coefficients were interpreted in relation to the reference category once it was determined that  $\beta_j$  should be set to zero for one of the categories in order to build the model.

**Table 1. Descriptive statistics of youth livelihood choices**

Variable Name	Description	Measurement
Dependent Variable		
Livelihood Choices	Categorical	1 if pursuing agriculture, 2 non-agricultural livelihood, 3 migration, 4 otherwise.
Explanatory Variable		
Gender	Sex of young people	The sex of youth is a dummy variable (coded as 1 male, 0 otherwise).
Education	Educational level of youth	The educational level of respondent is a dummy variable (coded as 1 Higher education, 0 otherwise).
MaritalStatus	The marital status of youth	The marital status of youth is a dummy variable (coded as 1 married and, 0 otherwise).
FarmLand	Size of Farm land ownership	The size of farm land is a continuous variable measured per hectare
PCareerPre	Parents career preferences for their family members	Parents career preference is a dummy variable (coded as 1 non-agricultural, 0 otherwise) that describes the youth parents' career preference for them (youth).

Variable Name	Description	Measurement
AgriViability	Views on Viability of agriculture in fulfilling the basic needs	Agricultural viability is a dummy variable (coded as 1 Yes, 0 otherwise) that shows the perceptions of youth whether agriculture is viable means of livelihood or not for them. Here, 'Yes' indicates youth views of agriculture as an economically viable or sufficient means of livelihood, and 'No' refers to the views of youth that indicate agriculture is not a viable or sufficient means of livelihood.
AgriConditions	The conditions of local agriculture	The conditions of local agriculture is a dummy variable (1 improved, 0 otherwise) that shows the views of youth whether there is improvement in the conditions of agriculture or not. For this variable, 'improved' agricultural conditions indicates the views of youth that show their belief that agriculture is advanced and supported by technology. On the other hand, "not improved" refers to youth views indicating their belief that agriculture is not advanced or supported by technology.
Liveprestige	The status of livelihood in agriculture	The status of livelihood in agriculture is a dummy variable (1 Yes, 0 otherwise) that shows the views of young people whether agriculture is prestigious means of livelihood for young people or not. For the status of livelihood in agriculture, 'Yes' represents the views of youth who believe that engaging in agriculture is prestigious and respected. Conversely, 'no' signifies that youth perceive a career in agriculture as lacking in both respect and prestige.

Source: Own elaboration

### Defining dependent and independent variables

These independent variables (Table 1) were identified based on the previous literature, which shows the need for comprehensive research on youth livelihood choices and their engagement in agriculture. Access to land (Amare et al., 2024; Holden & Tilahun, 2021; Moreda, 2023), education (Tauzie, 2025), gender roles (Ogunjimi et al., 2023), the economic viability of the sector (Abay et al., 2021), the conditions of agriculture (Sumberg et al., 2024), the parental influences, and the status associated with livelihood in agriculture (Korzenevica, 2021) were identified as a factor that may affect youth aspirations and livelihood in agriculture.

### Multinomial logit Assumption Tests

While using this model, the researchers have taken the assumptions of independence of estimators' variables and multicollinearity. Thus, with a maximum VIF of 2.353 for educational status of young people and all VIF values falling below the generally accepted threshold of 10, the VIF result demonstrated that there were no significant multicollinearity issues with the explanatory variables included in the model.

### Ethical considerations

Throughout the research process, strict adherence to ethical standards was maintained, including obtaining ethical approval and clearance prior to data collection. Permissions were secured from local administrators at all levels, with clear communication of the study's objectives and participants' rights to withdraw at any time. Special care was taken with minor participants, aged 15 to 17, by obtaining informed consent from their parent, in line with national laws. Throughout all stages, ethical considerations such as informed consent, confidentiality, and voluntary participation were prioritized to ensure the

integrity and ethical soundness of the study.

## RESULTS AND DISCUSSION

### Results of the Study

#### *Socio-economic characteristics of youth and their livelihood choices*

This section presents youth livelihood choices. It presents the comparison of youth livelihood choices with respect to socio-economic and demographic factors. The study participants were asked about their livelihood choices and the place of agriculture in their livelihood choices. The frequency and degree of association between categorical variables and the youth livelihood choices indicated in Table 2. The majority of young people, accounting 30%, have planned to adopt pursuing non-agricultural livelihood.

The study revealed that the highest number of youth (62.1 percent) aspired to means of livelihood other than agriculture. Table 2 show that only 37.9 percent of youth considered agriculture as a means of their livelihood

Table 2. Descriptive statistics of youth livelihood choices

Independent variables		Youth livelihood choices			Association		
		Livelihood options in percent			$X^2$ Value	P Value	
		Agriculture	Non-agriculture	Migration			
<b>Gender</b>	Male	31.4	8.1	26.7	0.8	16.195	0.012**
	Female	18.1	6.3	7.7	0.8		
<b>Education</b>	No higher education	42.2	2.5	6	-	108.179	000***
	Higher Education	7.3	11.6	28.4	1.7		
<b>FarmLand</b>	00	7.7	8.2	18.1	0.4	59.088	000***
	.25-.50	28.8	5.6	13.7	1.2		
<b>PCareerPre</b>	1.00 and more	12.9	0.4	2.5	-	46.395	0000***
	Agricultural	38.3	11.2	12.5	0.4		
<b>MaritalStatus</b>	Non-agricultural	3.8	10.3	21.9	1.2	33.326	000***
	Not Married	14.2	9.9	21.1	1.7		
<b>Agriability</b>	Married	35.3	4.3	13.3	0	7.890	.045**
	No (Not sufficient)	16.3	10.7	25.8			
<b>AgriConditions</b>	Yes (Sufficient/ viable)	33.2	3.4	8.6	0.4	8.690	.0033**
	Not improved	29.5	9.4	20.6	0.4		
<b>Liveprestige</b>	Improved	20	4.7	13.7	1.2	6.195	.103
	No (Not prestigious)	28.8	9	25.8	0.8		
	Yes (Prestigious)	20.6	5.1	8.6	0.8		

Notes: \*, \*\*, \*\*\* mean statistically significant at 10%, 5%, and 1% respectively

Source: Own Survey, 2023

As shown in Table 2, compared with male youth (31.4%), less percentage of female youth, 18.1%, respectively, have plans to pursue agriculture in their locality. Compared to male youth, very low percentage of females have low migration plan to migrate into other areas in search of better livelihoods.

Moreover, youth with higher education were inclined to look to nonagricultural employment and/or migration in search of better means of livelihood than youth with no higher education where higher percentage of them (42.2%) preferred pursuing agriculture in the locality. For the majority of young male and female respondents, farming and related livelihoods were viewed as less desirable than jobs outside the sector. Educated youth (graduates or those with higher education) who want to work in the formal sector or migrate (to cities or overseas) were especially supportive of this viewpoint.

Higher numbers of youth (more than 40%) with comparatively with better land holdings have planned to pursue agriculture, whereas very few youths with no landholding have planned to do agriculture as a means of their livelihood. On the other hand, for youth with their parental career preference is agriculture significant numbers of youth have planned to

use agricultural career as a means of livelihood. This may show the role of family influence on the livelihood choice of young people. Regarding the relationship between marital status and youth livelihood choice, significant percentage of married youth (35.3) planned to pursue agriculture as a means of livelihood compared to unmarried youth in the locality. Additionally, on the views of youth on the economic viability of agriculture in fulfilling their basic needs, significant numbers of youth who view agriculture is sufficient in fulfilling their basic needs have planned to join agriculture as a means of livelihood. On the contrary, most youth who view agriculture as insufficient in fulfilling economic demand planned to either migrating to other place in search of better livelihood or they have a plan to find no-agricultural livelihood. Moreover, significant percentage of youth who have positive view on the conditions of agriculture has planned to pursue agriculture as a means of livelihood compared to who have negative view on the conditions of local agriculture.

Thus, there is a strong and statistically significant relationship between youth livelihood choice and individual characteristics such as gender, parental career preference, marital

status, educational level, perception of the economic viability of agriculture, and the view on current conditions of agriculture, as indicated by the chi-square statistic of 22.42 (Table 2). This finding supports the view that the individual characteristics and socio-economic conditions of agriculture greatly influence youth life aspirations and their decision on agricultural livelihood, with graduate youth being more likely to choose agriculture and less educated young people being more likely to choose non-agricultural livelihood and migration as alternative means of livelihood. In Table 2, the chi-square value indicates an association between the categorical variables being analyzed, while the p-value shows whether frequencies differ significantly from what would be expected.

**Model testing and its robustness**

To determine the influence of socio-economic and demographic variables on livelihood options, a multivariate logistic regression analysis was conducted. A multinomial logistic regression was performed to model the relationship between youth livelihood options and socioeconomic and demographic characteristics. According to the independence of irrelevant alternative(IIA) assumption, the existence of more options has no bearing on the relative probability of selecting any two options(Vijverberg, 2011).

Thus, compared to the null hypothesis,  $X^2$  (df = 24; N = 232) = 255.152,  $p < 0.001$  the predictor variables in the model that just included the intercept fits the data better. Furthermore, with respect to the goodness-of-fit result of a multinomial logistic regression, it is widely noted that a statistically significant result ( $p < 0.05$ ) is suggestive that the model is a poor fit for the data (Hair, 2011). The model, however, is a good fit for the data since the p-value for the Pearson chi-square is 0.998. The “goodness of fit” shows that the Pearson’s

chi-square test shows that the model fits the data well [ $X^2(411) = 332.778, P = .998$ ]. Similarly, the deviation chi-square does indicate a good fit [ $X^2(411) = 211.192, P = 1.000$ ].

**Determinants of rural youth livelihood Choices**

Researchers have employed the relative risk ratio to elucidate the results of the multinomial logit model due to its superior comprehensibility regarding risk or probability (Cumings, 2009). Relative risk is commonly described as the ratio of the probability of an outcome occurring in one group compared to the probability of the outcome in a baseline category (Doi et al., 2022).

Based on the multinomial regression results, with pursuing of agricultural livelihood as the reference, the study estimates factors like farmland size, educational level, gender, local agricultural conditions, the economic viability of the sector, parental career preferences and perceptions of agricultural career associated status influence youth preferences among nonagricultural jobs, migration and other means of livelihood. It compares the likelihoods of youth choosing agricultural career, nonagricultural employment, migrating as alternative livelihoods or other means of livelihood. Thus, estimating the place of agriculture in young people's envisioned futures of livelihood was the main goal of this study; pursuing agricultural livelihood was utilized as the reference category for the parameter estimates.

Under the assumption of ceteris paribus, multivariate logistic regression analysis (Table 3) indicated that youth's likelihood of pursuing agriculture, nonagricultural jobs, migration as a livelihood strategy and other livelihood choices are significantly influenced by gender, landholding size, educational level, economic viability and the conditions of agriculture in Bure Zuria Woreda. The details of the analysis are described as follow;

**Table 3. Results of the multinomial logit model for determinants of youth livelihood aspirations**

	Non –agriculture		Migration		Other	
	B	p-value	B	p- value	B	p-value
<b>Intercept</b>	-2.487	.010	-3.483	.000	-21.455	.000
<b>Gender</b>	1.117	.054	2.139	.000**	1.209	.305
<b>Marital Status</b>	.104	.885	.562	.384	-17.656	.998
<b>Education</b>	2.908	.000**	3.752	.000**	19.310	.
<b>Agriability</b>	-1.419	.020*	-1.459	.004**	-1.893	.146
<b>AgriConditions</b>	-1.32	.024*	-1.202	.049*	-1.003	.427
<b>Liveprestige</b>	.251	.637	-.472	.298	.418	.709
<b>FarmLand</b>	-2.772	.005**	-1.670	.009**	-1.637	.425
<b>PCareerPre</b>	1.188	.039*	.895	.059	.925	.466

Notes: Reference category: pursuing agriculture.

Model Fitting Information: Log Likelihood = 255.152; chi-square = 177.213; df = 24; p-value < 0.001

Goodness of fit: Pearson’s chi-square 332.778 =; df = 411; p-value = 0.998

Deviance chi-square = 211.192; df = 411; p-value = 1.000

Pseudo R-Square: McFadden = 0.359; Nagelkerke = 0.607; Cox and Snell = 0.534

\*, \*\*, \*\*\* mean statistically significant at 10%, 5%, and 1% respectively

Source: Own Survey, 2023

**Farmland:** For land size, the likelihood of youth considering nonagricultural jobs decreases as land size increases; specifically, landowners are 2.772 times less likely to consider nonagricultural jobs compared to pursuing agriculture as land size increases by one hectare.

Moreover, the likelihood of migration in search of better opportunities decreases as land size increases. Specifically, youth with land access increase by one point, and migrating to seek alternative livelihoods decreases 1.67 times, making them less likely to migrate in search of better alternatives compared to pursuing agriculture. If youth respondents with land are limited to choosing between pursuing agriculture and migration in alternative livelihoods, the probability of migrating in search of better opportunities is approximately 62.5% ( $1.67 / (1 + 1.67)$ ), while the probability of pursuing agriculture is 74.66%.

The finding shows that land holdings increase the likelihood choosing agriculture as a sustainable means of livelihood. Consistent with this finding interview participants pointed that size of land ownership influences young people's willingness to remain in agriculture, with those having better land access often viewing farming as a temporary livelihood rather than a long-term career. For example, during interviews with young farmers in Tiyatiya, one of the participant stated:

I have inherited more than two hectares of land from my family. In this area, this amount of land is uncommon among young farmers, who often own larger plots. My land can produce enough to meet my household's basic needs, but I am not interested in remaining here and have plans to pursue a livelihood different from agriculture (Male Farmer Tiyatiya Kebele, January 2023).

**Education Status:** The relative risk ratio for non-agricultural livelihood, which is 3.908, indicates that the likelihood of selecting non-agricultural livelihood as opposed to pursuing agriculture increases by a factor of 3.908 when young people's level of education increases, *ceteris paribus*. The study suggests that young people with better levels of education significantly affect their livelihood choices, increasing their likelihood of abandoning agriculture and preferring to find non-agricultural jobs as a means of livelihood.

The value of the relative risk ratio for migration looking for alternative livelihood, which is 3.752, implies that when the level of education increases, the odds of choosing migration as a livelihood strategy in Bure Zuria Woreda, relative to joining agriculture as a means of livelihood, increase by a factor of 3.752 as other variables remain constant.

The multinomial logistic regression result of the survey shows that level of education was a strong predictor of youth engagement in agriculture. Young people without formal education or only basic education are more likely to rely on farming for their livelihoods compared to those with better formal education. The latter group tends to seek nonagricultural jobs locally or consider migration. The regression results indicate that, all things remaining constant, a higher level of formal education among youth tends to reduce their employment in agriculture as a viable livelihood option. The qualitative data further support this, indicating a substantial disparity between

youth groups in their livelihood choices. For many, farming appears to be the primary livelihood for individuals with lower levels of education. FGD with female farmers at Shakua one of the participant mentioned:

I only completed basic education and have no aspirations beyond agriculture. My main goal is to improve my income through agricultural activities, such as fattening oxen and engaging in other related pursuits (FGD with female farmers at Shakua, January 2023).

#### **Another participant also added:**

Since I have very limited education, I have confined myself to agriculture and related activities, such as herding animals and fattening livestock, as my primary livelihood (FGD with female farmers at Shakua, January 2023).

An interview with the key informants mentioned that the youth have not been trained that the agriculture sector is promising for youth livelihood; rather, it has been considered a job for less successful people in their formal education. The KII with Bure Woreda Labor and Skill Office representative stated:

The education system and curriculum tend to de-emphasize agriculture-related learning in schools. As a result, we have trained our youth to aspire to urban white-collar jobs, a goal that is often incompatible with the current availability of employment opportunities (KII with Woreda Labor and Skill Office, January 2023).

**The conditions of agriculture:** The conditions of agriculture in this study were contextualized as the degree in which the sector of agriculture integrated an improved methods and technology in local agricultural productions. The condition of agriculture in Bure Zuria woreda was found to be significant in affecting the livelihood choices of young people. The coefficient in terms of the relative risk ratio for non-agricultural livelihood and migration implies that when young people access better conditions in agriculture, the odds of choosing non-agricultural livelihood and migration as livelihood strategies as opposed to pursuing agriculture decrease by 56.82% and 54.58%, respectively. The result suggests that an improvement in the conditions of agriculture can increase the likelihood of young people engaging in agriculture as a means of livelihood. Similarly, one of the interview participant Kuch locality pointed that "the condition agriculture at its current state is not attractive for most youth. There is very limited access for improved production and use of technology in agriculture."

**Economic Viability of agriculture:** The economic viability of agriculture affects the livelihood choice of young people. The coefficients for non-agricultural livelihood and migration in the multinomial logit model are -1.419 and -1.459, respectively, which are statistically significant at less than 5%. The value of -1.419 and -1.459 means that, when all other factors remain constant, the probability of selecting non-agricultural livelihood and migration over pursuing agriculture decreases by a factor of 1.419 and 1.459 for every unit increase in the log of initial capital expenditure. This finding indicates that young people are approximately 1.419 and 1.459 times more likely to engage in non-agricultural livelihoods and migration

than to pursue agriculture if they perceive that agriculture is less viable to cover the basic costs of their livelihood, which is detrimental to their aspirations.

During the interviews, the study also identified that older youths often face challenges related to household food security and income expenditures. For example, during FGD, the young male farmer in Tiya-tiya mentioned, "We are here because we have no options. This [agriculture] sector is not appealing. However, if circumstances permitted, we would prefer to find promising jobs outside of agriculture."

**Gender:** The relative risk ratio for migration for searching alternative livelihood, which is 2.139, indicates that the likelihood of migrating for searching alternative livelihood as opposed to pursuing agriculture increases by a factor of 2.139 for males. The study suggests that gender significantly affects youth livelihood choices; males are more likely to migrate than females looking for other livelihood alternatives in the study area. During the interviews, participants in IDIs and FGDs mentioned gender-related constraints. For example, one IDI participant noted, "migration to find livelihood in a neighboring region is difficult for females. The conflict and ethnic-related problems expose us to gender-based abuse, and I prefer to stay here rather than expose myself to danger."

**Nearby family Career Preferences:** The nearby family, like parents, affects livelihood decisions of young people. The relative risk ratio for non-agricultural livelihood, which is 1.188, indicates that the likelihood of selecting non-agricultural livelihood as opposed to pursuing agriculture increases by a factor of 1.188 when young people's parents prefer non-agricultural livelihood. The study suggests that young people nearby family members' livelihood choices for non-agricultural jobs increase youth likelihood of abandoning agriculture as a means of livelihood.

## Discussion of the Findings

### *Socio-demographic variables shaping youth aspiration and livelihood choice*

The study revealed that sociodemographic factors have influenced youth livelihood choice. The result of quantitative and qualitative data align with a study indicating that youth livelihood choices are associated with gender, age, parental career preferences and education level play role in shaping youth livelihood strategies (Endris et al., 2022; Mukwedeya & Mudhara, 2023). The study found that a significant difference was observed between youth groups regarding their livelihood options, with youth possessing higher education levels showing a greater inclination toward non-agricultural jobs and migration in search of better opportunities.

Based on the quantitative and qualitative data, the educational level has caused the youth to have an aspirational orientation away from rural, agrarian livelihoods, where most youth with higher education. The study found that male youth with higher education primarily prefer migration while young farmers primarily focus on diversification of livelihood on on-farm and non-farm activities highly dependent on the resources of father farmer as their primary livelihood. A study by Holden and Tilahun (2021) showed that education influ-

ences young people's occupational choices and the rural youth are shifting away from agriculture and preferring nonagricultural occupations.

Moreover, increased education level appears to drive youth to migrate to other locations in pursuit of better opportunities. As reported by Ankrah Twumasi et al. (2019) a study by in Ghana indicated that increased levels of education and attendance at tertiary institutions have a negative effect on young people's decision and intensity to engage in farming. Thus, the study found that for the better educated youth, the rural areas have only little options for their aspired dreams and aspirations expected from their formal educations. The study shows that for graduates looking for "wider" alternatives where the rural areas have only little options for their aspired dreams and aspirations expected from their formal educations. Thus, engaging in agriculture as a means of livelihood is not an attractive for many young people in rural areas (Sumberg et al., 2017) especially for youth with higher education, though farmers without formal education find agriculture a means of sustaining their livelihood. As pointed by Ghosh and Roy (2022) individual educational attainment has an inverse relationship with agricultural activities and that education enables local youth to gather more information and to move outward. Sharma and Bhaduri (2009) also reported that skilled youth with nonfarm skills are more likely to leave agriculture and pursue nonagricultural careers.

The results of the study show that the promise of education in securing the formal employment that young men and women seek is rarely fulfilled, and they largely continue to farm in their family's production (Elias et al., 2018). Classical and modern sociologists such as Durkhiem (Worsley, 1956) and Parsons (Parsons, 1964) have long argued that modern education is an agency of socialization though which, in addition to learning knowledge and skills, children are considered particular norms and attitudes toward work and society. Moreover, education has inflated the aspirations and expectations of youth for the future, creating a gap between young people's professionals and the opportunities that are available to them in rural areas (Sumberg et al. 2014). This is why youths who have received tertiary education are less likely to engage in agricultural activities (Agwu, Nwankwo, and Anyanwu 2014).

Gender was also found to affect aspiration and livelihood in agriculture. Consistent with findings from other developing countries—where girls face significant constraints in pursuing agricultural activities and gender disparities often restrict women's roles as farmers (Ogunjimi et al., 2023)—the survey and interview results indicate that women encounter more barriers in agricultural livelihoods than men.

This study has also captured the role of parents' career preference influence youth livelihood choices in agriculture, aligning with (Ogunjimi et al., 2023) who found that parents' own aspirations and farm characteristics correlate with youth livelihood aspirations in agriculture. The study found correlation between parents' livelihood aspiration for their children and their propensity to envision farming, as well as between fathers general aspirations and children's aspirations toward farming. Adolescents absorb expectations from significant others, particularly family members and family-related role

models, through adaptation and adoption processes motivated by status attainment thinking which may shape expectations for work employment (Esche & Böhnke, 2024).

### ***Rural Youth Livelihood Choices and Opportunity Space***

Access to land is key factors that shape young people's opportunities. The study found that likelihood of exploring nonagricultural jobs in the locality instead of pursuing agriculture decreases as land size increases. This finding is consistent with a study in Nigeria, which reported that the larger the expected land inheritance, the lower the likelihood that a young person will engage in nonagricultural activities, and the greater their chances of remaining in agriculture (Amare et al., 2024). The current study strengthens the report that limited access to agricultural land forces youth to abandon agricultural employment in search of other sound sources of income (Bezu & Holden, 2014). It is argued that land inheritance significantly lowers the likelihood of leaving agriculture, which increases employment in agriculture and reduces rural-to-urban permanent migration (Kosec et al., 2018).

The study found that a scarcity of land, and a scarcity of employment opportunities in rural areas forced youth to leave agriculture as a means of their livelihood. In contrast, the likelihood of migration in search of better alternatives instead of pursuing agriculture decreases as land size increases. As the prospect of gaining access to land has become more challenging, young people are increasingly engaging in labor migration to find work elsewhere. Thus, as to the previous study (Bezu & Holden, 2014) access to land is very important for young people sustainable livelihood in agriculture.

The study also showed that young people in the study area have viewed agriculture as a means of livelihood is not only economically viability and sustainable and the conditions is less attractive. The interviews also witnessed the labor burden in agriculture and their views of low agricultural mechanization contributed for their satisfaction on agriculture. Thus, youth view and satisfaction on agricultural livelihood were affected their occupational aspiration in agriculture compared to a non-farm livelihood (Ogunjimi et al., 2023).

Thus, youth aspirations and choice of livelihood in the study area were the result of both constrained options to limited opportunities and economic viability of livelihood in rural areas, and individual and household factors. Aspirations and livelihood are never simply individual (Appadurai et al., 2004) which can be facilitated or constrained by the opportunity structures (Abay et al., 2021) and youth frequently adjust their aspirations based on emerging opportunities and barriers that arise as they navigate through different stages of life (Marzi, 2022).

Finally, contrary to the previous studies (Ankrah Twumasi et al., 2019) related to the status of agriculture the effect was not significant in the study area in determining the participation of the youth population in farming.

## **CONCLUSION**

Youth aspirations and choice of livelihood were the result of both constrained options to limited opportunities and eco-

nomics viability of livelihood in rural areas, and individual and household factors. The study reveals that youth without land ownership are more likely to leave their localities in search of better livelihoods. The findings suggest that aspirations for non-agricultural jobs and migration are driven not only by land scarcity but also by education levels, the economic viability, and conditions of agriculture. Thus, efforts to foster agricultural employment should consider the complex social, educational, gender, and household factors influencing youth decisions. The conceptualization of youth livelihood choices needs to be revisited to develop sustainable employment strategies based on the actual realities faced by youth. Youth livelihood choices may have local contexts and the study was limited to Ethiopia's specific district to understand the role of socio-economic, individual, and household characteristics in shaping young people aspiration and their livelihood choices. Thus, further study should be conducted that incorporate different research methods, geographic locations, economic, social and development contexts.

This study is limited to a specific district in Ethiopia, which may affect the generalizability of the findings regarding youth aspirations and livelihood choices across different geographic and youth contexts. This paper is part of a PhD dissertation, and the data analysis and report writing took more than two years after the data collection stage. The result of the report shows the facts during the time of the data collection. Finally, despite the limitations, the findings can serve as a valuable reference for researchers and policymakers working on youth employment and sustainable livelihood in agriculture.

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## **DATA AVAILABILITY STATEMENT**

The authors confirm that the data gathered are included in this manuscript, and any additional data supporting the findings of this study are available from the corresponding author upon request.

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# ASSESSMENT OF FACTORS INFLUENCING THE CONSUMPTION OF LOCAL DRINKS IN RURAL OSUN STATE, NIGERIA: POLICY RECOMMENDATIONS FOR SMALL-SCALE FOOD BUSINESS DEVELOPMENT

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**Abstract:** *Locally produced drinks play a significant role in the cultural, economic and culinary lives of rural dwellers in Nigeria. However, factors influencing their consumption remain poorly understood. This study investigated these critical factors among local drink consumers in rural areas of Osun State, Nigeria with a view to suggesting policy recommendations for the development of small-scale local food business. It employed a multistage sampling procedure to select 205 respondents. Primary data collected with a structured interview schedule and in-depth interview guide were analysed using descriptive statistics and factor analysis. The study revealed that many (52.1% and 83.0%) of the respondents were male and married, respectively, mean age was 40±12 years while mean household size was 6 persons. Zobo (100%), palm wine (99.5%), and soymilk (95.6%) were the most available local drinks in the study area. The sensory characteristics (63.45%), production (66.96%), and functional characteristics (74.03%) of the drinks were mostly considered by the consumers. The factors influencing consumption were the characteristics of the drinks, the educational background, and the economic status of the consumers. The study concluded that the identified factors were essential to the development of the local drinks industry and the small-scale food business in the study area. Policy recommendations that could provide a framework for this development were suggested based on the findings of the study.*

**Keywords:** *Local drinks, Consumption, Policy and factors*  
(JEL code: Q18)

## INTRODUCTION

To achieve sustainable rural development, it is important to support small-scale food businesses that use conventional food processing technologies and require little capital investment. These business categories are capable of creating jobs in rural areas, thereby minimising the social issues resulting from rural-urban migration. They are also essential for reducing post-harvest food losses and for improving the food supply chain. Experiences from large, mechanized processing plants in Nigeria and other West African nations highlight the potential success of small-scale food industries that incorporate limited mechanization of traditional processing techniques, particularly in rural areas where raw materials are sourced. Traditional, cost-effective food processing methods form the foundation of small-scale food enterprises in West

Africa, making substantial contributions to the economy (Ani-mashaun, Akangbe & Fakayode, 2013).

A steady and balanced food and water supply is necessary for people to maintain their ideal health and nutritional needs. When people's diet is inadequate, their productivity and achievement are significantly hindered (Marshall & Mejia, 2011). Local drinks provide an excellent alternative to conventional soft drinks. They are gradually gaining public acceptance, increasing consumption across developing countries (Anyanwu, 2019). Many local ingredients are utilized in the creation of diverse array of these drinks using local technologies. These include fruit juices, ginger drinks, soymilk, kunun-zaki, zobo, and many other non-alcoholic drinks. They are made by fermentation or extraction from processed Nigerian foods (Animasahun et al., 2019). Many native drinks and made in Nigeria through microbial fermentation are signifi-

cant and have a direct impact on the health and socioeconomic status of people.

Although Nigeria offers a wide variety of traditional processed drinks, only a few, such as kunun-zaki, pito, zobo, and nunu are more well-liked than others (Adeola & Aworh, 2010). This is because different people have different ideas about making these drinks and can add twists or packaging to make them more palatable for consumption. Among many others, the prevalent ones in the research region include zobo, soy milk, palm wine, and kunu. Zobo drink has numerous health benefits due to its closeness to nature and plenty of minerals, vitamins, and antioxidants (Adeniji, 2017). The capacity of zobo drink to treat high blood pressure, high cholesterol, disturbed digestion, and inflammatory issues is just one of its many health benefits (Olayemi, Adebayo, Muhammad & Bamishaiye, 2011). Soy milk is another typical locally produced drink in the research region. Soybeans are a plant variety renowned for their high protein content. Its byproducts include milk, sauce, and other items with added value. Products made from soy are growing in popularity, particularly with health-conscious consumers. Soy milk contains many isoflavones. Isoflavones are the primary and distinctive advantage of soy milk. Numerous health advantages of isoflavones include lowering cholesterol, relieving menopausal symptoms, preventing osteoporosis, and lowering the risk of developing certain cancers, such as breast and prostate cancer (Kant & Broadway, 2015).

As a result of civilisation, industrially produced soft drinks are highly consumed while their distinct flavour, taste and their ability to quench thirst further encourage their consumption (Redondo, Gómez-Martínez, & Marcos, 2014). These qualities are determined by the ingredients used including sugar for sweetness, carbonated water (water infused with carbon dioxide to alleviate intense thirst), and flavouring agents to enhance the beverages' taste profile (Adams, Rauf, & Akano, 2020). It has been reported that Nigeria consumes about 38 million litres of soft drinks yearly, placing it as the fourth largest soft drink consumer globally (Ehi-eromosele et al., 2022). Furthermore, Orji et al. (2019) noted a rise in the prevalence of diabetes in Abuja's rural communities. This observation could be because residents of rural areas, like their urban counterparts, also perceive that commercially produced carbonated drinks are superior to those made locally.

Yet, given Nigeria's growing urbanization, rise in the demand for commercial drinks, and heightened emphasis on sustainable agriculture transformation through the value chain framework, it becomes imperative to investigate the consumption of indigenous drinks among rural dwellers who are the main actors in agricultural transformation. Moreso, that, only healthy farmers can actively participate in farming and other rural development activities intensify the concern. The numerous health benefits of local drinks make them a healthy substitute for carbonated beverages. However, various unexplored factors may influence the consumption of these drinks among rural dwellers. Therefore, this study aimed to ascertain the types and characteristics of the drinks available and consumed among rural dwellers and investigate the factors influencing their consumption.

## MATERIALS AND METHODS

This study was conducted in Osun State, Nigeria. The study population consisted of rural dwellers who are familiar with the available local drinks in the study area. A multistage sampling procedure was employed to select respondents for the study. The first stage involved purposive selection of five Local Government areas (LGAs) based on history of existence and/or prevalence of indigenous drinks in the selected LGAs. These are: Ayedire, Ife East, Obokun, 3 Ila and Odo-otin LGAs. Proportionate sampling technique was utilized in the second stage to select one-tenth of the total number of communities in each of the selected LGAs translating to 10 communities from Ayedire LGA, 15 from Ife east, 10 from Obokun, 3 from Ila and 3 from Odo-otin making a total of 41 rural communities. Finally, five rural dwellers familiar with indigenous drinks were selected from each rural community using snowballing technique to give 205 respondents for the study. Additionally, two indigenous drink producers from each LGA were chosen to partake in the in-depth interviews.

Data for the study were collected using a structured interview schedule and analyzed using SPSS software while simple descriptive statistics such as frequency counts and percentages, means and standard deviation were used to summarize the data collected. The characteristics of the local drinks investigated in the study include sensory characteristics, socio-cultural, production and functional characteristics. To measure the drink sensory characteristics, respondents were asked to indicate which of the five sensory characteristics of local drinks (taste, appearance, colour, viscosity, flavor/smell) affect their consumption of local drinks. The highest obtainable score was fifty (50), and the minimum was zero (0). Three socio-cultural characteristics, namely; religious compatibility, cultural compatibility, and social status compatibility were also examined by asking respondents to indicate whether or not they considered these characteristics in their choice of the drink(s) to consume. The maximum obtainable score was thirty (30), and the minimum score was zero (0). Production characteristics were also examined in terms of the cleanliness of the processor, packaging material, cost of the packaging material, cost of the drink, and temperature of the drink at serving (hot/room temperature/chilled). The maximum obtainable score was forty (40), and the minimum was zero (0). Lastly, the functional characteristics of the drinks were examined via the medicinal use and the feel-good factor. The maximum obtainable score was twenty (20), and the minimum was zero. The overall maximum and minimum obtainable drinks' characteristics scores were 140 and 0 respectively.

Factor analysis was used to isolate factors influencing the consumption of local drinks among rural dwellers in the study area. Variables were grouped using principal component analysis with varimax rotation. The cut-off point for constant loading was 0.30, and the constant loading of less than 0.30 was discarded. Kaiser's criterion was also used to determine the factor to retain in the analysis result. Thus, factors with an Eigenvalue greater than one were retained. The factors were thereafter named based on the following criteria as employed by (Alabi et al., 2013). First, synonyms of each factor's most

heavily loaded variables were selected. Next, names were retained based on the similarity of the features exhibited by the variables contributing to the factors. Subsequently, a joint explanation or interpretation of the positive and highly loaded variables was conducted. Finally, the researcher's subjective interpretation of experiences gleaned from relevant literature was incorporated into the naming process.

## RESULTS AND DISCUSSION

The Socio-economic characteristics of the respondents

Results in Table 1 showed that 47.1 percent of the respondents were within the age range of 20 to 40 years with a mean age of  $39 \pm 12$  years. Age is a pivotal factor used in measuring any individual's biological intellectual maturity and experience (Famakinwa et al., 2019). These results indicated that a more considerable proportion of the rural dwellers who consume local drinks were still young and in their active age of productivity. This implies that the respondents might be consuming the drinks to make them energetic enough to conduct their day-to-day activities without feeling exhausted. This supports the claim by Rydzik et al. (2020) whose study confirms that while older individuals may feel energetic for activities they value, they might experience greater exhaustion following physical tasks than younger adults.

A good number (52.9%) of the respondents were male

while 41.1 percent were female. This implies that there were more males than females among the rural dwellers sampled for this study. This could indicate that males in rural areas prefer local drinks, unlike their urban counterparts who usually dominate the centres where foreign alcoholic drinks are sold. This finding contradicts those of Zannou et al. (2022), who reported in their study on traditional fermented foods and microbiological safety and health benefits that females consume more fermented traditional drinks than their male counterparts. The majority (83.0%) of the respondents were married implying a sense of responsibility because marriage holds significant value in Yoruba communities.

Also, the majority (88.3%) of the respondents were Yoruba with 80.1 percent indigenes of their respective communities. This is expected since the study area is located within the Yoruba ethnic group of Nigeria. Furthermore, most (79.6%) of the respondents indicated their preference for local drinks, while few (20.4%) preferred carbonated drinks. This implies that most rural dwellers placed more value on locally produced drinks than on carbonated ones, probably because of the perceived health and nutritional benefits of most of the local drinks. This aligns with the research of Ukwuru and Monday (2018), who found out in their work that there is a high prospect for local drinks in Nigeria because of high patronage and acceptance.

**Table 1. Distribution of respondents by their selected socio-economic characteristics**

Variables	Frequency	Percentage	Mean	Standard Deviation
<b>Sex</b>				
Male	108	52.9		
Female	97	47.1		
<b>Religion</b>				
Christianity	143	69.9		
Islam	53	25.7		
Traditional	9	4.4		
<b>Marital Status</b>				
Single	23	11.7		
Married	171	83.0		
Divorced	3	1.5		
Widowed	8	3.9		
<b>Ethnicity</b>				
Yoruba	182	88.3		
Hausa	19	9.8		
Igbo	4	1.9		
<b>Household size</b>				
<5	80	1.9	6	2
5-10	112	76.3		
11-15	13	19.9		
<b>Age</b>				
<20	13	6.3	39	12
20-40	97	47.1		
41-60	84	41.3		
>60	11	5.3		
<b>Preferred drink</b>				
Indigenous	163	79.6		
Carbonated	42	20.4		

Source: Field Survey, 2023

\*=Multiple responses

### Types of available and consumed local drinks in the study area

Results in Table 2 implies that all (100.0%) the respondents indicated availability of zobo drink in their locality, vast majority (99.5%) indicated palm wine, the vast majority (95.6%) indicated soymilk, the vast majority (93.7%) indicated kunu, vast majority (91.7%) indicated pito, vast majority (90.8%) indicated the availability of ogogoro, more than half (57.8%) indicated tiger nut milk, almost half (50.2%) indicated burukutu while few (30.6% and 30.6%) of the respondents indicated the availability of agadagidi and nunu drinks in the study area. It could be deduced that most of the identified local drinks were readily available across the study area.

**Table 2. Types of indigenous drinks available and consumed in the study area n=205**

Indigenous drinks*	Available		Consumed	
	Freq	%	Freq	%
Zobo	205	100.0	149	72.7
Palm wine	204	99.5	131	64.4
Soymilk	197	95.6	131	63.9
Kunu	193	93.7	127	61.9
Pito	189	91.7	80	39.0
Ogogoro	187	90.8	71	34.6
Tiger nut milk	119	57.8	62	30.2
Burukutu	103	50.2	32	15.6
Nunu	63	30.6	20	9.8
Agadagidi	63	30.6	13	6.3

Source: Field Survey, 2023

\*=Multiple responses

### Characteristics of the local drinks

#### Sensory characteristics of the local drinks based on the number of consumers per drink

The results in Table 3 revealed that taste is the most considered sensory characteristic by most consumers of zobo (69.8%), nunu (62.5%), palmwine (83.9%) agadagidi (53.8%) and burukutu (50.0%) drinks. On the other hand, viscosity of the drink was the most considered by consumers of kunu zaki (96.1%), soymilk (84.4%) and tiger nut (52.1%) drinks. This agrees with Olufunke and Oluremi (2015), who posited that taste, aroma, colour, and consistency/viscosity affect the overall acceptability of kunu zaki and soymilk. The finding implies

This agrees with the findings of Nwaiwu et al. (2020), who in their work asserted that the prevalent indigenous beverage in Nigeria includes soymilk, nunu (fermented cow milk), tiger nut milk, kunu, zobo, palm wine, and the local beers pito and burukutu amongst others.

The majority (72.7%) of the respondents indicated that they consumed zobo, about two-thirds (64.4% and 63.9%) soymilk and palm wine, followed by kunu (61.9%), pito (39.0%), tiger nut milk (34.6%), ogogoro (30.2%), 15.6 percent consumed nunu, very few (9.8% and 6.3%) of the respondents consumed burukutu and agadagidi as their preferred local drinks. This implies that zobo, soymilk and palm wine were the major local drinks consumed in the study area.

that local drink producers should ensure that the characteristic taste of the respective drinks is preserved in the production process while the viscosity of the milk-like drinks should be prioritized.

The following in-depth interview excerpts buttress the above findings:

*'Some people like slightly peppery things, which is the reason why we add ginger to the zobo to give it a peppery taste' (a zobo producer in Odo-otin LGA)*

*'Why some consumers will not drink kunu is because they feel the taste is not sweet. Since they are only used to taking sweet things, they would prefer buying sweet zobo (a kunu producer in Ayedire LGA).*

**Table 3. Sensory characteristics of the local drinks based on the number of consumers per drink**

Local drink*	Taste Freq (%)	Appearance Freq (%)	Colour Freq (%)	Viscosity Freq (%)	Flavour Freq (%)
Zobo	104 (69.8)	95 (63.8)	23 (15.4)	9 (6.0)	95 (63.8)
Kunu zaki	106 (83.5)	111 (87.4)	28 (22.0)	122 (96.1)	11 (8.7)
Soymilk	111 (84.1)	103 (78.0)	28 (21.2)	112 (84.4)	10 (7.6)
Tigernut milk	31 (43.7)	32 (45.1)	25 (35.2)	37 (52.1)	12 (16.9)
Nunu	20(62.5)	18 (56.3)	17 (54.2)	18 (56.3)	11 (34.4)
Pito	49(61.3)	69 (86.3)	70 (87.5)	54 (56.3)	20 (25.0)
Palmwine	110 (83.9)	63 (48.1)	65 (49.6)	49 (37.4)	59 (45.0)
Ogogoro	26(41.9)	19 (30.6)	53 (85.5)	49 (79.0)	15 (24.2)
Agadagidi	7(53.8)	4 (30.8)	3 (23.1)	3 (23.1)	1 (7.7)
Burukutu	10(50.0)	7 (35.0)	6 (30.0)	5 (25.0)	2(10.0)

Source: Field Survey, 2023

\*=Multiple responses

### ***Socio-cultural characteristics of the Local drinks based on the number of consumers per drink***

Results in Table 4 showed that religion compatibility of the drink was the most important consideration among consumers of zobo (93.3%), soymilk (72.7%), kunu zaki (69.3%), pito (61.3%) and nunu (59.4%) while cultural compatibility was most considered among consumers of ogogoro (65.2%), agadagidi (61.5%) and burukutu (55.8%). On the other hand, most of the palm wine (85.4%) and tiger nut milk (78.9%) consumers considered social status. The results revealed that religious compatibility is the most considered socio-cultural characteristic by most consumers across the various indigenous drinks. The finding suggests that Nigeria is a religious

country and that Nigerians consider their religion in all things in line with Magbadelo (2003). In addition, cultural compatibility is the next consideration, implying that local drink consumers find the drinks compatible with their culture. This shows that their production should be prevented from going into extinction to protect the consumers' cultural heritage.

The following in-depth interview excerpts buttress the above finding.

'There are people do not consume alcoholic drinks because of their religion. We have both Muslims and Christians in this community, although, there are few who do not consider religion but many will only buy the non-alcoholic ones' (A producer in Obokun LGA).

**Table 4. Socio-cultural characteristics of the local drinks based on the number of consumers per drink**

Local drink	Religious compatibility	Cultural compatibility	Social status compatibility
	Freq (%)	Freq (%)	Freq (%)
Zobo	139 (93.3)	71 (47.7)	126 (84.6)
Kunu zaki	88 (69.3)	71 (55.9)	48 (37.8)
Soymilk	96 (72.7)	32 (24.2)	55 (41.7)
Tiger nut milk	42 (59.2)	26 (36.6)	56 (78.9)
Nunu	19 (59.4)	5 (15.6)	10 (31.5)
Pito	49 (61.3)	46 (57.5)	33 (41.3)
Palm wine	73 (55.7)	110 (83.9)	127 (85.4)
Ogogoro	38 (57.5)	43 (65.2)	16 (24.2)
Agadagidi	6 (46.2)	8 (61.5)	3 (23.1)
Burukutu	7 (35.0)	11 (55.0)	5 (25.0)

Source: Field Survey, 2023, \*=Multiple responses

### ***Production characteristics of the local drinks based on the number of consumers per drink***

The results in Table 5 revealed that the cleanliness of the processor was the most important production characteristic for most consumers across the various local drinks. The finding implies that local drink processors should ensure that they are always clean, and that the processing is done in a neat environment. In addition, the cost of the drink is another factor most of the consumers considered, this implies that no matter how much rural dwellers love to consume these drinks, if they are not affordable, they will not be consumed.

The following in-depth interview excerpts buttress the

above finding.

'One of the reasons some people do not consume locally produced drinks is because they are not sure of the source especially the type of water used in the production of the drinks and the environment. Some producers are dirty and some pick used soft drink bottles here and there and use them to bottle their drinks for sales' (A producer in Ife East LGA).

'When the drink is too expensive, people will not buy it as most of them will settle for cheaper alternatives. One need to consider the environment and purchasing power of the people to produce the quality they can afford' (A producer in Ila LGA).

**Table 5. Production characteristics of the local drinks based on the number of consumers per drink**

Local drinks*	Cleanliness of the processor	Packaging materials	Cost of the drink	Temperature of the drink
	Freq (%)	Freq (%)	Freq (%)	Freq (%)
Zobo	141 (94.6)	109 (73.2)	73 (48.9)	100 (67.1)
Kunu zaki	115 (90.6)	99 (77.9)	63 (49.6)	107 (84.8)
Soymilk	100 (75.8)	71 (53.8)	61 (46.2)	88 (66.7)
Tigernut milk	41 (57.7)	24 (33.8)	51 (71.8)	30 (42.3)
Nunu	19 (59.4)	10 (31.3)	20 (62.5)	11 (34.4)
Pito	33 (41.3)	24 (30.0)	37 (46.3)	47 (58.8)
Palm wine	102 (77.8)	32 (24.2)	66 (50.4)	17 (12.9)
Ogogoro	33 (53.2)	27 (43.5)	27 (43.5)	10 (16.1)
Agadagidi	9 (69.2)	1 (7.7)	8 (61.5)	1 (7.7)
Burukutu	10 (50.0)	4 (20.0)	8 (40.0)	3 (15.0)

Source: Field Survey, 2023

\*=Multiple responses

### **Functional characteristics of the local drinks based on the number of consumers per drink**

It can be inferred from the results in Table 6 that the specific medicinal and feel-good function of consuming the various local drinks affect their consumption by the respondents in the study area. This corroborates with the finding of Oscar et al. (2023) who asserted that local drinks had improved product shelf life, quality, and safety due to the beneficial microorganisms generated, nutritional and bioactive compounds such as

organic acids, antioxidants, enzymes, vitamins, minerals, high bioavailable proteins, peptides,  $\beta$ -glucans and amino-acids amongst others. The following in-depth interview excerpt buttresses the above finding

*'Those who know the harm that sugar causes in the body and the great health benefits of consuming local drinks do not hesitate to consume it once its available to them' (A producer in Odo-otin LGA).*

**Table 6. Functional characteristics of the local drinks based on the number of consumers per drink**

Local drink*	Medicinal function	Feel good function
	Freq (%)	Freq (%)
Zobo	135 (90.60)	80 (53.69)
Kunu zaki	107 (84.25)	83 (65.35)
Soymilk	76 (58.02)	81 (61.83)
Tiger nut milk	52 (83.87)	42 (67.74)
Nunu	17 (85.00)	9 (45.00)
Pito	67 (83.75)	17 (21.25)
Palm wine	95 (72.52)	81 (61.83)
Ogogoro	47 (66.20)	57 (93.44)
Agadagidi	9 (69.23)	12 (92.31)
Burukutu	15 (46.88)	12 (37.50)

Source: Field Survey, 2023

\*=Multiple responses

### **Factors influencing the consumption of local drinks among rural dwellers.**

Results in Table 7 show the various factors rotation pattern, with measures that are highly loaded on each of the three factors isolated. Variables were grouped using principal component analysis with varimax rotation. The cut-off point for constant loading was 0.30 and the constant loading less than 0.30 was discarded. The results further show that factors loaded explained 87.918 percent of variance in all while

unknown factors explained the remaining 12.082 percent of variance. The contribution of each of the highly loaded factors influencing the consumption of the drinks was also shown as follows: drinks characteristics factor was mostly associated with the consumption of local drinks in the study area with a 39.923 percent contribution, followed by the literacy factor (30.908%) and economic factor (17.087%). Results in Table 8 showed the variables that significantly contributed to each of these three influencing factors.

**Table 7. Results of principal component analysis showing the initial Eigen value for factors influencing the consumption of local drinks**

S/N	Factors	Eigen value	% of variance	Cumulative %
1	Drink characteristics factor	4.392	39.923	39.923
2	Educational factor	3.400	30.908	70.831
3	Economic factor	1.880	17.087	87.918
4	Unknown factor	<1.000	12.082	100.00

Source: Field Survey, 2023

#### **Drink characteristics factor**

Results in Table 8 reveal that six variables significantly contributed to this factor. These were socio-cultural characteristics (L= 0.986), functional characteristics (L = 0.985), sensory characteristics (L = 0.965), production characteristics (L= 0.961), years spent in formal education (L= -0.522) and household size (L = 0.440). The factor was named based on criterion two- retaining the name based on the similarity of the features reposed in the variables contributing to the factors. This implies that characteristics of the drink such as taste, colour, appearance, flavour, packaging, medicinal functions, feel-good factor, cultural compatibility, religious compatibility, social status compatibility, cleanliness, cost effectiveness

amongst others, would significantly influence the consumption of the indigenous drink in the study area. This is in tandem with the submission of Nwagu et al. (2017) who asserted in their work that social influences together with local cultural norms are central factors that influences the consumption of local drinks.

#### **Educational factor**

Results in Table 8 show that six variables significantly contributed to this factor. These were: years spent in formal education (L=0.944), perception of the respondents towards the local drinks (L= -0.445), knowledge of perceived health benefits of the drinks (L=0.850), constraints (L= -0.819),

household size ( $L = 0.731$ ) and estimated annual income ( $L = 0.470$ ). The factor was named based on criterion one- picking synonyms of the highest loaded variables on each factor. This implies that the level of formal education attained will make the respondents to be informed and expose to various information on the nutritional values of indigenous drinks which will in-turn influence indigenous drinks consumption among the respondents.

### **Economic factor**

Results in Table 8 show that variables that significantly contributed to economic factor were annual income ( $L = 0.931$ ), age ( $L = 0.777$ ), and knowledge of perceived health benefit ( $L = 0.500$ ). Criterion one (picking synonyms of the highest loaded variables) was used to name the factor. This implies that when there is economic stability, the respondents will be financially buoyant to purchase the drinks.

**Table 8. Results of principal component analysis showing the variables contributing to factors influencing the indigenous drinks consumption**

Factors and contributing variables	L	L <sup>2</sup>	$\lambda$
<b>Drink characteristics factor</b>			
Socio-cultural characteristics	0.986	0.972196	
Functional characteristics	0.985	0.970225	
Sensory characteristics	0.965	0.931225	
Production characteristics	0.961	0.923521	
Years spent in formal education	-0.522	0.272484	
Household size	0.440	0.193638	<b>4.263</b>
<b>Educational factor</b>			
Years spent in formal education	0.944	0.891136	
Perception of the respondents towards the local drinks	-0.445	0.198025	
Knowledge of perceived health benefit	0.850	0.722521	
Constraints	-0.819	0.670761	
Household size	0.731	0.534361	
Annual income	0.470	0.220917	<b>2.347</b>
<b>Economic factor</b>			
Annual income	0.931	0.866761	
Age	0.777	0.603729	
Knowledge of perceived health benefits	0.500	0.253862	<b>1.720</b>

*L* = Loading factors,

*L*<sup>2</sup> = Square of loading factors

$\lambda$  = Latent root for the factor (summation of the square loading)

Source: Field survey, 2023

## CONCLUSION

The study concluded that varieties of drinks including zobo, palm wine and soymilk were locally produced and consumed in the study area while the sensory, socio-cultural and production characteristics of the drinks were considered among consumers. Factors influencing the consumption of local drinks in the study area include the drink characteristics factor, the educational background, and the economic status of consumers. Based on the findings of this study, some policy recommendations were suggested with a view to providing a framework for the development of the local drink industry and the small-scale local food business at large. These include but not limited to policies that could enhance provision of capacity building training for local drink/food producers particularly in rural areas to improve their production skills and knowledge; promote local drink/food consumption through awareness programmes on radio, television and social media; establish standards for local drink/food production to ensure quality and consistency for consumers' protection from con-

taminated/adulterated products; ensure high standards of hygiene and sanitation among producers to improve the safety and quality of local drink/food; and develop a quality control system to ensure compliance to high standards of quality and safety of the local drink/food. It is assumed that if the suggested policy recommendations are well implemented, monitored and evaluated, they are capable of effectively promote the production and consumption of local drink/food and support the overall development of small-scale local food business in the rural area.

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# SOCIO-ECONOMIC DRIVERS AND INSTITUTIONAL CHALLENGES OF TOBACCO CONTRACT FARMING PARTICIPATION IN SVOSVE COMMUNAL AREA, ZIMBABWE

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**Abstract:** Tobacco remains Zimbabwe's leading agricultural export crop, increasingly produced under contract farming arrangements. While contract farming offers inputs, technical assistance, and assured markets, concerns persist that benefits are skewed towards merchants rather than smallholder farmers. This study investigates the determinants of smallholder participation in tobacco contract farming in Ward 22, Svosve Communal Area, Marondera District, Mashonaland East Province. Guided by the New Institutional Economics (NIE) theory, which emphasizes the role of institutions in reducing transaction costs under market imperfections, a mixed methods approach was employed. Quantitative data were collected from 246 communal tobacco farmers using structured questionnaires, while qualitative insights were gathered from 10 key informant interviews with agricultural business advisory officers (ABAO), tobacco merchants, and farmer leaders. Multistage sampling was used to select five villages: Mere 1, Mere 2, Mere 3, Neshamba, and Bonda. Data were analyzed using descriptive statistics and multiple linear regression in SPSS v25. Higher The regression model was statistically significant ( $F = 24.73$ ,  $p < 0.001$ ) with a strong explanatory power ( $R^2 = 0.68$ ; Adjusted  $R^2 = 0.65$ ). Results showed that landholding size ( $\beta = 0.62$ ) and years in contract farming ( $\beta = 0.45$ ) were the strongest positive predictors of participation, followed by irrigation access ( $\beta = 0.38$ ), household income ( $\beta = 0.31$ ), and education level ( $\beta = 0.29$ ). In contrast, multiple income sources ( $\beta = -0.27$ ) and years in general agriculture ( $\beta = -0.27$ ) negatively influenced participation, indicating that diversified and highly experienced farmers were less inclined to join contracts. The discussion highlighted that resource endowments and institutional support drive participation, while lack of collateral and financial literacy hinder broader inclusion. The study concludes that contract farming remains a viable pathway for smallholder integration into value chains but requires reforms to ensure equitable benefits. Policy implications emphasize collateral support, farmer training, and resource provision particularly land development and irrigation infrastructure to enhance participation and productivity among smallholder farmers.

**Keywords:** Tobacco, Contract Farming, Smallholder Farmers, Zimbabwe, New Institutional Economics, Participation (JEL code: Q13)

## INTRODUCTION

Contract farming has emerged as a dominant financing model in Zimbabwe's tobacco sector, particularly after the Fast Track Land Reform Programme (FTLRP) of 2000. The FTLRP redistributed large-scale commercial farms to smallholder and communal farmers, many of whom lacked collateral, capital, and access to formal credit. Tobacco, being Zimbabwe's leading agricultural export crop, quickly became central to these new farming arrangements. By 2025, tobacco

accounted for more than 60% of agricultural exports and contributed significantly to national GDP, making it a cornerstone of Zimbabwe's agro-based economy (TIMB, 2025; Pangapanza-Phiri, Mungatana, & Mhondoro, 2024).

Smallholder farmers, however, face structural challenges in accessing inputs, credit, and reliable markets. Without collateral such as title deeds, they are excluded from formal banking systems. Contract farming emerged as a surrogate institution, where merchants provide inputs (seeds, fertilizers, chemicals), technical assistance, and guaranteed markets

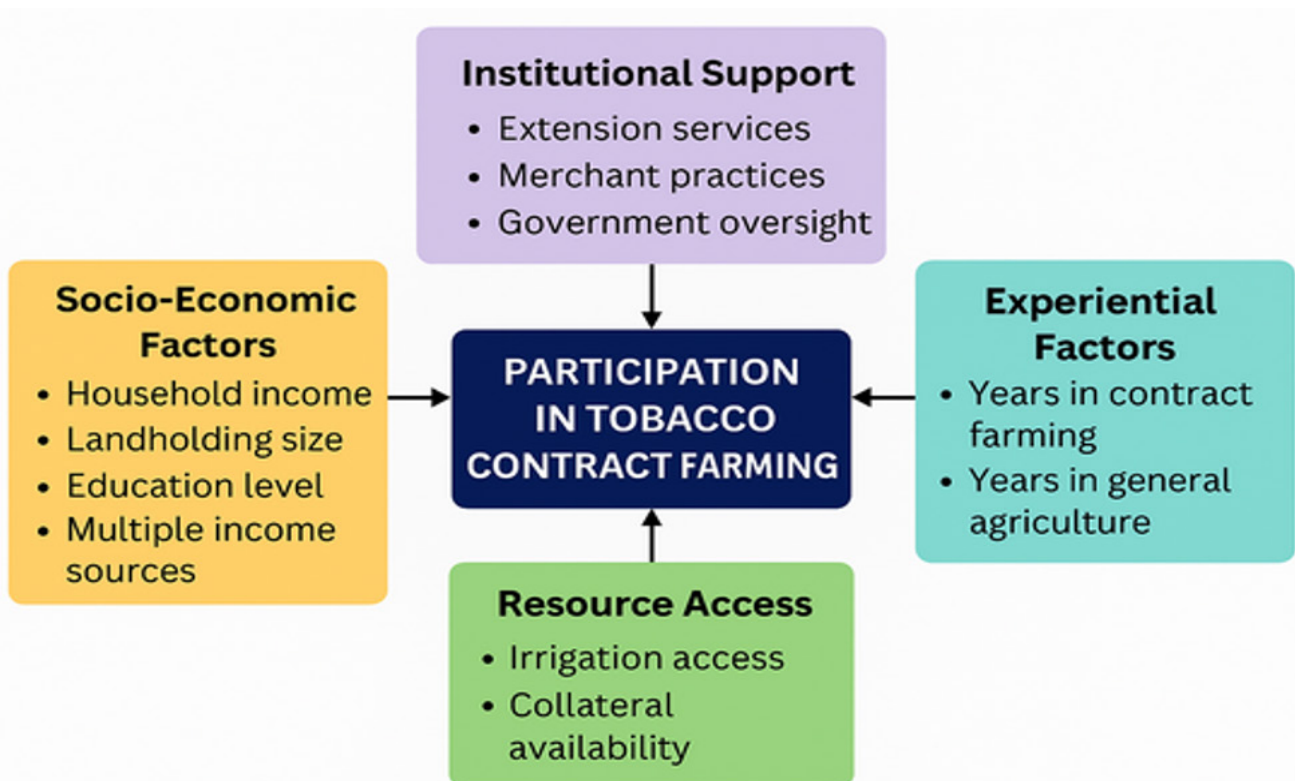
in exchange for farmers' commitment to deliver their crop. While this arrangement has expanded production and stabilized supply chains, debates persist regarding fairness. Evidence suggests that merchants often capture disproportionate benefits through pricing mechanisms, grading systems, and debt recovery practices, leaving farmers vulnerable to exploitation and income insecurity (Mango, Setoboli, Tshuma, & Sibanda, 2025; Gatawa, 2025).

The New Institutional Economics (NIE) theory provides the conceptual lens for this study. NIE emphasizes the role of institutions in reducing transaction costs and coordinating production under imperfect markets. In Zimbabwe, contract farming functions as such an institution, bridging gaps in credit and input supply. However, the institutional arrangements also determine power relations between farmers and

merchants, shaping participation and outcomes. Understanding these dynamics is critical for assessing whether contract farming empowers smallholders or entrenches dependency (Mhondoro, 2024; Scoones, 2025).

The problem statement is that, despite the potential economic benefits of contract farming, smallholder farmers in Svosve face challenges such as capital constraints, lack of bargaining power, and exploitative contractual terms. Participation is rising, yet many farmers remain insecure and indebted. There is limited empirical evidence on the socio-economic and institutional factors that determine participation in tobacco contract farming in Zimbabwe, particularly at the communal level. This study therefore seeks to fill that gap by examining the determinants of smallholder farmers' participation in tobacco contract farming in Svosve Communal Area.

**Figure 1. Conceptual framework: Socio economic drivers and institutional challenges of tobacco contract farming participation**



Source: Own evaluation

The conceptual framework in fig 1 illustrates how smallholder farmers' participation in tobacco contract farming is influenced by four interconnected categories: socio-economic factors, resource access, experiential factors, and institutional support. Each category contributes distinct drivers such as income, landholding, education, irrigation, farming experience, and access to extension services that shape farmers' capacity, motivation, and eligibility to engage in contract arrangements. Arrows from each category point toward the central outcome, showing that participation is not determined by a single factor but emerges from the combined influence of per-

sonal resources, institutional structures, and prior experience. This directional flow reflects the New Institutional Economics theory, emphasizing how institutions and resource endowments reduce transaction costs and coordinate production under market imperfections.

## MATERIALS AND METHODS

The study was conducted in Svosve Communal Area, located in Ward 22 of Marondera District, Mashonaland East Province, Zimbabwe. Marondera District comprises 23 wards,

and Ward 22 was purposively selected because of its favourable climatic conditions for tobacco production. The area lies within Natural Region II, which is characterized by relatively high agricultural potential, receiving an average annual rainfall of between 750 mm and 1,000 mm and mean temperatures ranging from 15°C to 28°C. These conditions make the area suitable for intensive crop production, particularly tobacco, maize, and horticultural crops. The soils are predominantly sandy loams, and farming systems are mixed, combining crop cultivation and livestock rearing. Tobacco is the dominant cash crop, grown alongside maize, groundnuts, and small grains, while cattle and goats provide draught power, manure, and household food security. Farmers in this area are beneficiaries of the Fast Track Land Reform Programme (FTLRP) and operate under communal tenure, which limits their access to formal credit since they lack title deeds.

A multistage sampling procedure was employed to select respondents. At the first stage, Marondera District was selected due to its prominence in tobacco production. From the 23 wards, Ward 22 was purposively selected based on its favourable climate and high concentration of tobacco growers. Within Ward 22, Svosve Communal Area was identified as the study site. At the next stage, five villages Mere 1, Mere 2, Mere 3, Neshamba, and Bonda were purposively selected because they are actively engaged in tobacco production and exhibit variation in resource endowments and levels of contract farming participation. Following village selection, farming households were randomly sampled from within these villages to ensure representativeness. From a population of 3,500 communal tobacco farmers, a sample of 246 farmers was determined using the Krejcie and Morgan (1970) sample size determination formula. In addition, 10 key informants comprising extension officers, tobacco merchants, and farmer leaders were purposively selected to provide in depth qualitative insights. Quantitative data were collected using structured questionnaires administered to farmers, with responses captured digitally through KoboCollect and later exported into SPSS version 25 for analysis. Key informant interviews were conducted to complement the quantitative findings with institutional and experiential perspectives.

Data analysis was conducted at two levels. Descriptive statistics were used to summarize socio-economic characteristics of contracted and non-contracted farmers, focusing on variables such as years of education, number of income sources, years in agriculture, arable land size, irrigation access, and gender distribution. These statistics provided comparisons between contracted and non-contracted farmers. To identify determinants of participation in tobacco contract farming, a multiple linear regression model was applied, with hectares under contract farming as the dependent variable representing the degree of participation. Independent variables included average monthly household income, years in agriculture, years in contract farming, arable land size, irrigation access, education level, and gender.

The regression model is expressed as:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \epsilon_i \dots \dots \dots 1$$

Where:

$Y_i$  = Hectares under tobacco contract farming (dependent variable)

$\beta_0$  = Intercept

$X_{1i}$  = Average monthly household income

$X_{2i}$  = Years in agriculture

$X_{3i}$  = Years in contract farming

$X_{4i}$  = Arable land size (ha)

$X_{5i}$  = Irrigation access (dummy variable: 1 = access, 0 = no access)

$X_{6i}$  = Education level (years of schooling)

$X_{7i}$  = Gender (dummy variable: 1 = male, 0 = female)

$\epsilon_i$  = Error term

## RESULTS AND DISCUSSION

### Quantitative Results

#### *Descriptive Findings*

Table 1 shows the descriptive analysis. The statistics revealed clear differences between contracted and non-contracted farmers. Contracted farmers had higher education levels (mean 10.2 years), larger landholdings (mean 2.1 ha), and greater access to irrigation (65%), which made them more attractive to merchants. In contrast, non-contracted farmers had lower education levels (mean 7.8 years), smaller landholdings (mean 1.2 ha), and limited irrigation access (30%). Non-contracted farmers also tended to have more diversified income sources (mean 2.4 compared to 1.3) and longer farming experience (mean 12.1 years compared to 8.5 years), suggesting that they relied on multiple livelihood strategies rather than committing to contracts. These findings highlight the role of resource endowments and education in shaping participation.

**Table 1. Socio economic characteristics of contracted vs non contracted farmers (n = 246)**

Variable	Contracted Farmers (Mean/%)	Non-Contracted Farmers (Mean/%)
Years of Education	10.2 years	7.8 years
Number of Income Sources	1.3	2.4
Years in Agriculture	8.5 years	12.1 years
Arable Land Size	2.1 ha	1.2 ha
Irrigation Access	65%	30%
Gender Distribution (M/F)	58% / 42%	55% / 45%
Contract Participation	100%	0%

Source: Own evaluation

### Regression Analysis

Regression results in table 2 confirmed the descriptive trends. Positive predictors of participation included household income ( $\beta = 0.31$ ), landholding size ( $\beta = 0.62$ ), irrigation access ( $\beta = 0.38$ ), years in contract farming ( $\beta = 0.45$ ), and education level ( $\beta = 0.29$ ). These variables significantly increased the likelihood of farmers allocating more hectares to contract farming. Conversely, multiple income sources ( $\beta = -0.27$ ) and longer years in general agriculture ( $\beta = -0.27$ ) were negative predictors, indicating that farmers with diversified livelihoods or long experience outside contracts were less likely to par-

ticipate. This suggests that contract farming appeals more to resource-endowed households seeking stable markets, while experienced farmers with alternative income streams may avoid contracts due to perceived risks or exploitative terms.

These findings confirm that resource endowments and institutional support drive participation. Farmers with irrigation infrastructure and larger plots are attractive to merchants, while those with diversified livelihoods perceive contracts as restrictive. The imbalance of bargaining power between merchants and farmers remains a challenge, echoing literature that highlights exploitative tendencies in contract arrangements.

**Table 2. Determinants of participation in tobacco contract farming (Multiple Linear Regression)**

Predictor Variable	Coefficient ( $\beta$ )	Effect on Participation
Household Income	0.31	+
Landholding Size	0.62	+
Irrigation Access	0.38	+
Years in Contract Farming	0.45	+
Education Level	0.29	+
Multiple Income Sources	-0.27	-
Years in General Agriculture	-0.27	-

Source: Own evaluation

### Model Fit Statistics

- $R^2 = 0.68$  → the model explains 68% of the variation in participation.

- Adjusted  $R^2 = 0.65$  → after adjusting for the number of predictors, the model still explains 65% of the variation.

- F statistic = 24.73 → the overall regression model is statistically significant.

- P value < 0.001 → strong evidence that the predictors jointly influence participation.

### Interpretation

- The model shows that landholding size ( $\beta = 0.62$ ) and years in contract farming ( $\beta = 0.45$ ) are the strongest positive drivers of participation.

- Multiple income sources ( $\beta = -0.27$ ) and years in general agriculture ( $\beta = -0.27$ ) negatively affect participation, sug-

gesting that diversified or highly experienced farmers prefer autonomy.

- The high  $R^2$  and significant F statistic confirm that the model is robust and reliable for explaining participation patterns among smallholder farmers.

### Qualitative Results

Key informant interviews revealed contrasting perspectives among stakeholders in tobacco contract farming. Representatives from Northern Tobacco Company (1), Shasha Company (1), ZLT Company (1), and Munyasha (1) emphasized that contract farming has improved farmer access to inputs and stabilized supply chains, arguing that merchants provide critical support in the absence of formal credit. However, Government Agricultural Business Advisory Officers (ABAO) (4) noted that many smallholders remain disadvantaged, pointing

out that contracts often favor resource endowed farmers with irrigation and larger landholdings. Farmer leaders (2) strongly criticized the system, asserting that “the deductions of money after sale on the sales sheets are not clear and untraceable”, leaving farmers uncertain about their actual earnings. They further argued that grading practices are biased toward merchants, reducing farmer bargaining power. These assertions highlight both the supportive role of merchants in sustaining production and the persistent concerns about transparency and fairness raised by farmers and government officers.

### Discussion of Results

The results of this study show that participation in tobacco contract farming in Svosve Communal Area is strongly influenced by socio economic and institutional factors.

**Education and participation:** Farmers with higher education levels were more likely to participate in contracts. This agrees with Mango et al. (2025), who found that education improves farmers’ ability to interpret contract terms and comply with technical requirements. However, Scoones (2025) cautions that education alone does not shield farmers from exploitative grading systems, suggesting that institutional transparency is equally important.

**Landholding size and irrigation access:** Regression results confirmed that larger landholdings and irrigation access significantly increased participation. Merchants such as Northern Tobacco, Shasha, ZLT, and Munyasha supported this, noting that resource endowed farmers are more reliable suppliers. Yet, Government Agricultural Business Advisory Officers (ABAO) argued that this practice excludes poorer households, reinforcing inequality. This supports Gatawa (2025), who observed that contract farming tends to favor better resourced farmers.

**Household income and contract experience:** Higher household income and longer years in contract farming were positively associated with participation, indicating that financially better off households are more capable of meeting contractual requirements, absorbing production risks, and repaying input loans. This finding is consistent with New Institutional Economics theory (North, 1990; Williamson, 2000), which emphasizes that actors with greater financial capacity are better positioned to engage in institutional arrangements under conditions of risk and uncertainty. However, this relationship is potentially bidirectional. As noted by Mango et al. (2025) and Mhondoro (2024), higher income may enable entry into contract farming, while participation itself may also lead to income gains through improved access to inputs, markets, and technical support. Given the cross sectional nature of this study, the analysis captures associations rather than causal effects, and the direction of influence cannot be definitively determined. Qualitative evidence further complicates this relationship, as farmer leaders reported that income gains are frequently undermined by opaque and “untraceable” deductions on sales sheets, echoing concerns raised by Scoones (2025) regarding power asymmetries and transparency deficits. Addressing these trust concerns requires institutional reforms such as standardized and itemized sales statements, independent auditing of deductions, and strengthened regu-

latory oversight by agencies such as the Tobacco Industry and Marketing Board to enhance transparency and safeguard farmer incomes.

**Multiple income sources and general farming experience :** Farmers with diversified income sources or longer farming experience were less likely to participate. This agrees with Nyakuchena (2025), who found that diversified farmers avoid restrictive contracts to maintain autonomy. Merchants countered that diversification signals unreliability, while farmer leaders argued that experienced farmers distrust merchants due to past exploitative practices.

**Transparency and trust:** A recurring theme from interviews was lack of transparency. ABAO officers and farmer leaders criticized grading and deductions, while merchants insisted these were necessary to recover input costs. This disagreement highlights a trust deficit that undermines farmer confidence in contracts.

The study found that participation in tobacco contract farming in Svosve Communal Area is driven by education, landholding size, irrigation access, household income, and contract experience, while multiple income sources and longer general farming experience reduce participation. Key informants highlighted both benefits such as access to inputs and stable markets and challenges, including unclear deductions and biased grading. Overall, contract farming supports resource rich farmers but risks excluding poorer households. Greater transparency, equitable support, and improved infrastructure are essential for ensuring that contract farming contributes to rural development and poverty reduction in Zimbabwe.

**Long term debt risks for poorer households:** Although contract farming facilitates access to inputs and markets, it also exposes poorer households to long term debt risks, particularly where asset bases and income buffers are limited. Studies by Scoones (2025) and Gatawa (2025) show that in contexts of climatic shocks, price volatility, or pest and disease outbreaks, smallholder farmers remain liable for input loans even when yields are low or fail altogether. Evidence from this study further indicates that these risks are exacerbated by non transparent and “untraceable” input deductions, a concern similarly highlighted by Mango et al. (2025) and Mhondoro (2024). Repeated exposure to such conditions may entrench cycles of indebtedness among the poorest households, reinforcing dependency on merchants and restricting livelihood diversification. These findings highlight the need for safeguards such as transparent and itemized deduction systems, clearer contractual terms, risk sharing mechanisms including crop insurance, and stronger regulatory oversight by institutions such as the Tobacco Industry and Marketing Board, in line with recommendations by FAO (2025) and World Bank (2026), to prevent chronic indebtedness and promote equitable contract farming outcomes.

## CONCLUSION

Overall, the findings suggest that contract farming benefits resource rich households but risks excluding poorer farmers. Supportive arguments from extension officers emphasized the role of contracts in providing inputs and technical support,

while farmer leaders stressed the need for fairness and transparency. Policy interventions should therefore focus on collateral support, irrigation development, farmer training, and transparent contract enforcement to ensure equitable participation and sustainable livelihoods.

While this research has provided valuable insights into the determinants of smallholder participation in tobacco contract farming in Svosve Communal Area, several areas warrant further investigation. Future studies could:

- Expand geographic scope to include other districts and provinces, allowing for comparative analysis across different agro ecological regions.
- Examine long term welfare impacts of contract farming, including household income stability, debt accumulation, and food security.
- Assess gender dynamics, focusing on how men and women experience contract farming differently in terms of access to resources, decision making, and benefits.
- Investigate institutional transparency, particularly grading systems and deductions, to evaluate fairness and accountability in merchant practices.
- Explore alternative financing models, such as cooperative schemes or government backed credit, to compare their effectiveness with contract farming.

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# DETERMINANTS OF SMALL-SCALE MACADAMIA NUT PRODUCTIVITY IN ZIMBABWE: AN ORDINAL REGRESSION MODEL ANALYSIS

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**Abstract:** *This study determines the factors influencing macadamia nut productivity among smallholder farmers in Zimbabwe's Chipinge District. Despite favourable agro-ecological conditions, smallholder productivity (1.89t/ha) significantly lags behind commercial farmers (3.9t/ha) and global benchmarks (7.17t/ha). Using cross-sectional data from 284 registered smallholder farmers collected in 2023-2024, ordinal regression analysis identified critical productivity determinants. Results revealed that farming experience significantly increases productivity, with each additional year of experience raising the log odds of achieving higher productivity by 18.4% ( $p < 0.05$ ). Labour availability positively influences productivity ( $p < 0.05$ ), particularly during labour-intensive operations like pruning and harvesting. Farm resilience score, capturing innovations that reduce field losses and improve market access, exhibited a strong positive effect ( $p < 0.01$ ). Unexpectedly, financial management skills (FMS) and risk management skills (RMS) demonstrated significant negative effects ( $p < 0.05$ ), suggesting a "formalization penalty" where sophisticated management systems incur overhead costs that fail to yield proportional returns in contexts of pervasive market failure, price volatility, and liquidity constraints. The study concludes that while farm experience, labour capacity, and resilience-building investments enhance productivity, the effectiveness of formal management skills is constrained by fundamental market structure failures. Policy recommendations emphasize capacity building in experiential learning, labour skill development, resilience-enhancing technologies, and most critically the market structure reforms to enable formal management systems to function effectively. Addressing transaction costs, information asymmetry, and capital access constraints must precede investments in sophisticated farm management training.*

**Keywords:** *Macadamia nuts productivity, Farm management, Smallholder agriculture, Ordinal regression, Zimbabwe*  
(JEL code: Q02, Q13, Q18)

## INTRODUCTION

Agriculture contributes approximately 17% to Zimbabwe's GDP, supplies 60% of industrial raw materials, and supports 65% of the population (FAO, 2023). However, persistent low productivity among small-scale producers compromises competitive market participation and threatens rural livelihoods (Fortune, 2020). Macadamia nuts (*Macadamia integrifolia*), introduced around 2000 in Zimbabwe's Eastern Highlands, have emerged as a high-value export crop with significant poverty reduction potential. The global macadamia market is projected

to reach US\$4.5 billion by 2024, growing at a Compound Annual Growth Rate of 6% (Araya et al., 2023).

Chipinge District in Manicaland Province accounts for 45% of Zimbabwe's macadamia farmers and 47% of cultivated area. Despite favourable agro-ecological conditions including average annual rainfall of 1105mm and temperatures of 12°C, smallholder yields (1.89t/ha) fall hugely short of commercial farmers (3.9t/ha) and global benchmarks of 7.17t/ha achieved in Australia and South Africa (Bandason et al. 2022; Zuza et al. 2023). This 56% productivity gap represents a substantial economic loss for smallholder farmers and

threatens the sustainability of this emerging value chain.

Understanding the factors that influence productivity is critical for designing targeted interventions to close this gap. While technical knowledge exists among farmers (Bandason et al., 2021), productivity remains constrained by complex interactions between farm-level management capabilities, resource endowments, and external market conditions. This study addresses the research question: What factors significantly influence macadamia nut productivity among smallholder farmers in Zimbabwe?

### **The problem context, objective, and novelty**

Macadamia nut productivity among smallholder farmers in Zimbabwe has declined from approximately 54% in 2005 to 38% in 2020 (Agritex, 2023), threatening the viability of this poverty-alleviating cash crop. While farmers possess technical know-how in modern production techniques, productivity remains constrained by poorly understood factors related to farm management capabilities, resource availability, and market conditions. Farmers receive prices averaging only 50% of global benchmarks, with some receiving as low as US\$0.60/kg in 2023, making current returns insufficient to justify input investments.

Despite the crop's potential, comprehensive research on productivity determinants in Zimbabwe remains limited (Chikodzi, et al., 2021). Most existing studies have not adequately examined how farm management capabilities, labour dynamics, and resilience-building investments interact to influence productivity outcomes. This knowledge gap prevents policymakers and development practitioners from designing evidence-based interventions to enhance smallholder productivity and secure the sustainability of Zimbabwe's emerging macadamia value chain.

The objective of this study is to determine the factors influencing small-scale macadamia nut productivity in Zimbabwe, with specific focus on:

- o Farm and human capital factors (age, land size, experience, and labour availability).
- o Management capability factors (financial, technical, planning, risk management, and business management skills).
- o Farm resilience factors (innovations, market access, and climate adaptation).

This study makes several original contributions to the literature by being among the first to apply ordinal regression modelling to analyse macadamia productivity determinants among Zimbabwean smallholders. Unlike prior narrowly focused agronomic studies, it adopts a multidimensional framework examining human capital, farm management capabilities, labour dynamics, and farm resilience. A notable counter-intuitive finding, the "formalization penalty" associated with financial and risk management skills, challenges prevailing assumptions about formal farm management training in smallholder contexts. By situating these constraints within Zimbabwe's broader market failures, information asymmetry, and liquidity constraints, the study fills a critical knowledge gap (Chikodzi et al., 2021), generating actionable, evidence-based guidance for policymakers seeking to enhance the sustainability of Zimbabwe's emerging macadamia sector.

## **LITERATURE REVIEW**

### **Macadamia Production in Global and Regional Context**

Global macadamia production is dominated by Australia, South Africa, Kenya, and Hawaii, where technical efficiency exceeds 85% (Mokwite, 2022). In these regions, well-coordinated value chains support reliable supply to multiple markets, driven by increasing consumer demand for healthy foods. However, technical efficiency levels in most African countries remain below 40%, primarily due to low productivity levels, poor aggregate supply, and disconnected value chain functions (Mulo, 2022).

In Africa, Kenya provides lessons for value chain development, though challenges persist including lack of information on cultivars, inconsistent market data, and poor post-harvest handling (Maina, 2020; Materechera and Scholes, 2022). South Africa's macadamia market exhibits inefficiency, with demand progressively exceeding supply due to the gap between potential productivity (100kg/tree/annum) and actual productivity (34kg/tree/annum) (Materechera and Scholes, 2022).

### **Determinants of Agricultural Productivity**

Agricultural productivity is influenced by multiple interconnected factors. Farm and human capital including farmer age, education, experience, and labour availability provide the foundational capacity for production (Bouarakia et al., 2023). Management capabilities encompassing financial planning, risk management, and business acumen determine how effectively resources are deployed (Chingarande et al., 2020).

Farming experience enables farmers to navigate challenges including pest and disease management, input supply disruptions, and price fluctuations without compromising business operations (Bouarakia et al., 2023). However, the relationship between experience and productivity can be complex, as over-reliance on past practices may inhibit adoption of innovations (Weier et al., 2024).

Labour availability critically determines productivity in quality-sensitive crops like macadamia nuts, which require careful handling during pruning and harvesting to meet export market standards (Maina, 2020; Costa et al., 2020). The interaction between labour and technology adoption remains an important policy consideration, as inappropriate technology choices can displace labour without commensurate productivity gains (Fortune, 2020).

Farm resilience which is defined as the capacity to withstand shocks and adapt to changing conditions has emerged as a critical productivity determinant (Bhunu and Kwaramba, 2022). Resilience encompasses innovations that reduce field losses, climate adaptation strategies, and reliable market access (Zuza et al., 2023; Chingwaramusee, 2021). Large-scale farmers typically benefit more from resilience investments due to better access to ICT, finance, and early warning systems compared to smallholders (Mhlanga et al., 2020).

Financial and risk management skills theoretically enhance productivity by optimizing capital allocation and mitigating uncertainty (Chingarande et al., 2020). However, in contexts of severe market failure and liquidity constraints, the benefits

of sophisticated management systems may be undermined by structural barriers (Bouarakia et al., 2023).

Despite growing interest in macadamia production, significant research gaps persist in Zimbabwe's context. First, existing studies have not comprehensively examined how multiple farm management capabilities interact to influence productivity outcomes. Second, the relationship between formal management skills and productivity in resource-constrained, market-failure contexts remains poorly understood. Third, limited evidence exists on how farm resilience investments translate into measurable productivity gains for smallholder farmers. This study addresses these gaps through rigorous econometric analysis of productivity determinants.

**Theoretical Framework**

Transaction costs theory provides a lens for understanding how market inefficiencies constrain smallholder productivity. Transaction costs in Zimbabwe's macadamia value chain take the form of what Schaner (2016) describes as the "cost of inconvenience". This is the burden that farmers bear when participating in marketing activities. For small-scale macadamia nuts farmers in remote Manicaland province of Zimbabwe, these costs include:

- o Search and information costs: Farmers lacking real-time price data must physically travel to multiple collection points, incurring opportunity costs of lost farm labour and fuel expenditure to negotiate prices and verify buyer legitimacy.
- o Bargaining and contracting costs: The weak market power is as a result of being smallholder farmers with on average 5 hectares; thus, the production volume is low. Also, the cooperation between farmers towards one common product affects the production performance in the macadamia value chain. This also affects the high negotiation costs, resulting in not being able to retain bargaining power in value chains. Moreover, currently there is a lack of facilities such as certified drying facilities that can offer opportunities in contract farming.
- o Monitoring and enforcement costs: Selling to informal

middlemen carries high risk of delayed or defaulted payments. Farmers must expend effort monitoring transactions, which is a direct transaction cost that explains preferences for quick sales of lower-quality, undried nuts rather than investing in quality improvements.

Transaction costs constitute approximately 65% of total marketing costs among smallholder farmers in Zimbabwe (Mutami, 2015; Scoones et al., 2011). Middlemen exploit information asymmetry and farmers' lack of liquid capital, paying low prices that transfer all market uncertainty onto producers while extracting disproportionate profits through control of bulking and logistics functions. In this study, these transaction costs directly constrain productivity by:

1. Reducing effective prices received, thereby lowering incentives for productivity-enhancing investments.
2. Creating liquidity constraints that prevent timely purchase of inputs.
3. Forcing farmers to prioritize quick sales over quality improvements.
4. Limiting access to information about improved production practices.

**Conceptual Framework**

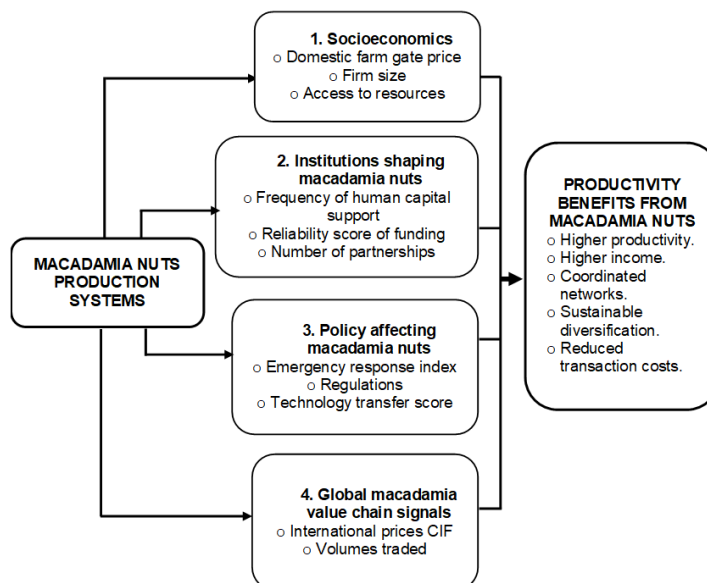
Figure 1 presents the conceptual framework guiding this study. The framework posits that smallholder macadamia productivity is determined by the interaction of three key domains:

Domain 1: Farm and Human Capital - Age, land size, farming experience, and labour availability provide the foundational capacity for production.

Domain 2: Management Capabilities - Financial management, technical skills, planning capacity, risk management, and business acumen determine how effectively resources are deployed.

Domain 3: Farm Resilience - Innovations that reduce losses, climate adaptation, and market access strategies enable farms to withstand shocks and capture opportunities.

**Figure 1. Conceptualizing macadamia nuts value chain functions and outcomes**



Source: Adapted from Aguiar de Medeiros et al. (2017).

These domains interact within a broader context shaped by transaction costs, market structures, and institutional arrangements. High transaction costs create a "formalization penalty" where sophisticated management systems incur overhead costs without yielding proportional returns due to market failures. This framework guided variable selection and hypothesis development for the empirical analysis.

## MATERIALS AND METHODS

### Study area, research design and sampling strategy

This 2024 study was conducted in Chipinge District, Manicaland Province, South-Eastern Zimbabwe (coordinates: 20.1938° S, 32.6206° E; elevation: 1132m). The area receives average annual rainfall of 1105mm with temperatures averaging 12°C, creating suitable conditions for macadamia cultivation alongside tea, coffee, and dairy farming. Chipinge accounts for over 43% of macadamia production in Manicaland Province and over 20% of national output.

The study adopted a pragmatic research philosophy, chosen for its flexibility in accommodating both quantitative and qualitative methods without ideological commitment to either paradigm. This enabled a more comprehensive understanding of macadamia productivity determinants than a single-method approach would allow. Mixed methods were employed to triangulate quantitative measurement of productivity determinants with qualitative insights into farm management challenges, thereby strengthening the validity and depth of findings. A cross-sectional survey design was selected for its cost-effectiveness and suitability for capturing farmer-level data at a single point in time across a geographically dispersed population. This design blended descriptive-exploratory and explanatory approaches:

the descriptive-exploratory strand served to characterize existing productivity patterns and surface emerging themes, while the explanatory strand established cause-effect relationships through rigorous econometric analysis. This provided both contextual understanding and statistically defensible conclusions.

Multi-stage sampling was employed with Manicaland Province and Chipinge District purposively selected based on macadamia nuts production dominance. The sample size was calculated using the formula suggested by Young (2016) with a known population (equation 1) and triangulated using the online sample size calculator (Calculator.net, 2026).

$$n = \frac{N}{\left[1 + N(e^2)\right]} \quad (1)$$

Where  $n$  = sample size,  $N$  = population (821 registered macadamia farmers), and  $e$  = precision level (0.05) for 95% confidence interval. A sample of 284 smallholder farmers was drawn through simple random sampling using random number generation. This is a technique chosen for its ability to eliminate selection bias and ensure every farmer in the sampling frame had an equal probability of inclusion, thereby enhancing the representativeness and generalizability of findings. Complementing this, 27 key informants were purposively selected, representing Agritex officers, buyers, processors, and farmer associations. Purposive sampling was deemed appropriate for this strand given the need to target individuals with specialized knowledge and institutional expertise in the macadamia value chain, whose insights would enrich the qualitative dimension of the study beyond what random selection could yield.

**Table 1. Population and sampling structure**

Sample cluster	Sampling technique	Research instrument to be used	Target population	Sample size
A1	Random	Questionnaire and Focus Group Discussion guide	530	228
A2	Random	Questionnaire and Focus Group Discussion guide	105	24
Estates	Purposive	Questionnaire and Key Informant Interview guide	5	5
Other stakeholders	Purposive	Questionnaire and Key Informant Interview guide	181	27
<b>Total</b>			<b>821</b>	<b>284</b>

Source: Survey analysis (2024)

### Data Collection

Primary data were collected in 2024 using a combination of approaches, with multiple data collection methods deliberately employed to capture the multifaceted nature of macadamia productivity determinants and reduce the limitations inherent in relying on any single instrument. Secondary data drawn from company records, farmer group reports, and policy documents complemented the primary data, providing historical context, institutional perspectives, and corroborating evidence that

strengthened the overall analytical framework and enhanced the credibility of the study's conclusions.

1. Structured questionnaires administered to farmers, covering: (A) socio-economic and demographic characteristics, land ownership, production patterns; (B) management capabilities across financial, technical, planning, risk management, and business domains; (C) farm resilience indicators including innovations, market access, and climate adaptation; (D) productivity outcomes measured in kg/ha.

2. Semi-structured key informant interviews with 27 stakeholders including Macadamia Growers Association representatives, Zimbabwe Farmers Union officials, Agritrex officers, middlemen, and processors to gain insights into value chain dynamics and productivity constraints.

3. Focus group discussions held during district and provincial development workshops enabled cross-stakeholder dialogue and triangulation of findings.

**Variable Selection and Measurement**

Variables were selected based on established agricultural economics literature and the study's conceptual framework,

ensuring theoretical grounding and relevance to the Zimbabwean macadamia context. The dependent variable, productivity, was deliberately categorized into three ordinal levels namely low, medium, and high based on kg/ha output relative to district averages. This categorization was adopted rather than treating productivity as a continuous variable, as it more accurately reflects the discrete, hierarchical nature of smallholder productivity outcomes and fulfils the distributional assumptions required for ordered logit regression. This made it the most statistically appropriate analytical technique for the data structure at hand.

**Table 2. Description of variables in the productivity model**

Variable	Description	Unit	Expected Effect
<b>Dependent Variable</b>			
Productivity	Categorical variable (1=low, 2=medium, 3=high)	Kg/ha	
<b>Explanatory Variables</b>			
Age	Age of principal decision maker	Years	+
Land size	Total land holdings	Hectare	+/-
Experience	Cumulative years farming macadamia	Number	+
Total labour	Total labour available (indexed by age)	Number	+/-
FRS	Farm Resilience Score (transformed from Likert scales)	Index	+
FMS	Financial Management Skills (transformed)	Index	+
BMS	Business Management Skills (transformed)	Index	+
PAS	Personal Attributes Score (transformed)	Index	+
TSS	Technical Skills Score (transformed)	Index	+
PSS	Planning Skills Score (transformed)	Index	+
RMS	Risk Management Skills (transformed)	Index	+

Source: Authors' own computation.

Management skill variables were constructed by transforming Likert scale responses measuring farmers' capabilities across multiple dimensions. The Farm Resilience Score captured innovations, climate adaptation, and market access strategies. The selected variables fall into two main categories: Farm and human capital (including age, land size, experience, and total labour, which measure the scale of operation and foundational knowledge), and Management skills (including variables for financial, technical, planning, risk management, and general business skills, all of which are transformed continuous variables designed to capture the quality and sophistication of the farmer's decision-making process). This comprehensive selection ensures the model tests how physical resources, experience, and the quality of farm management influence the farmer's likelihood of achieving a high, medium, or low productivity level.

**Analytical Framework**

Ordinal regression was employed to analyse productivity determinants. This technique allows examination of relationships between independent variables and a categorical dependent variable with natural ordering (low < medium <

high productivity). The model specification (Abid et al., 2020), follows:

$$P(Y \geq y_j | x) = \frac{1}{1 + \exp(\alpha_j + x' \beta)}, j = 1, 2, 3 \tag{1}$$

Transforming to logit form:

$$\log \left[ \frac{P(Y \geq y_j | x)}{1 - P(Y \geq y_j | x)} \right] = \alpha_j + x' \beta, \text{ for } j = 1, 2, 3. \tag{2}$$

Where  $P(Y \geq y_j | x)$  is the cumulative probability of an event ( $Y \geq y_j$ );  $\alpha_j$  is the respective constant term/intercepts and  $\beta$  is the vector of regression coefficients with the dimension of (p by 1) corresponding to the xi covariates.

Zeng et al. (2015) also noted that another critical interpretation of the ordinal logit regression model is the odds ratio which is the probability ratio of the sampled macadamia nuts farmers. The estimation of the logit model was done using the Maximum Likelihood (ML) method. In this research, the high

productivity cluster farmers were utilized as the reference group. As such, the form of odds ratios in natural logarithms (ln) for the farmers are as follows:

$$\ln \left[ \frac{P_{i1}}{P_{i2}} \right] = \alpha_{01} + \beta_{11} X_1 + \beta_{21} X_{21} + \beta_{31} X_3 + \dots + \beta_{n1} X_n + \mu_{i1}$$

(3)

$$\ln \left[ \frac{P_{i2}}{P_{i3}} \right] = \alpha_{02} + \beta_{12} X_1 + \beta_{22} X_2 + \beta_{32} X_3 + \dots + \beta_{n2} X_{n1} + \mu_{i2}$$

(4)

Where Probability of Pi1 (P (Y = 1)) if the farm has low productivity, Pi2 Probability (P (Y = 2)) if the farm has medium productivity, Pi3 probability (P (Y = 3)) if the farm has high productivity.

Regression coefficients are interpreted as the predicted change in log odds of being in a higher productivity category per unit increase in the independent variable, controlling for other variables (Liu, 2008).

Pilot testing ensured instrument validity. Cronbach's Alpha test yielded 0.889 for the questionnaire (81 items), exceeding the 0.60 threshold for acceptable internal consistency (Majeed, 2019). The key informant interview guide achieved 0.894. Data quality was ensured through researcher-administered questionnaires, digital recording of interviews, and systematic coding of qualitative data.

## RESULTS AND DISCUSSION

### Sample Characteristics and Response Rate

The study achieved a 93.7% response rate, with data collected from 266 of the targeted 284 farmers (246 A1 smallholders, 15 A2 smallholders, and 5 Estates). This response rate exceeds the 83% regional average, attributed to effective collaboration with extension officers who ensured respondent availability during data collection.

Productivity distribution revealed significant underperformance: 62.74% of farmers fell into the low productivity category (<1.5t/ha), 23.53% achieved medium productivity (1.5-2.5t/ha), and only 13.73% attained high productivity (>2.5t/ha). This distribution aligns with findings by Materechera and Scholes (2022) in South Africa's macadamia sector, confirming widespread technical inefficiency among smallholder producers in the region.

The median age of principal decision makers was 48 years (range: 26-75 years), comparable to the 44-year median reported by Weier et al. (2024) in macadamia orchard management studies. This indicates that macadamia farming in Zimbabwe is dominated by middle-aged to older farmers, with limited youth participation in the sector. Zuza et al. (2023) reported varying age ranges among extension agents supporting macadamia development in Malawi, highlighting the policy need for context-specific farm management interventions to avoid one-size-fits-all approaches.

**Table 3. Summary of the variables used in the model**

Variables	Frequency	%	Valid %	Cumulative %
<b>Productivity:</b>				
	<b>Min.</b>	<b>Max.</b>	<b>Mean/Median</b>	<b>Std. Dev.</b>
Age of Respondent	26	75	48.00	12.98
Farming Experience	3	50	12.50	9.83
Total Land Size	2.60	40.00	3.47	6.24
Labour Reliability Index	2.00	11.00	2.93	2.49
Weighted Resilience	1.57	5.00	3.30	0.74
Financial Management Score	1.58	4.33	2.81	0.67
Business Management Score	2.10	4.70	3.19	0.69
Personal Attributes Score	2.38	5.00	3.69	0.57
Technical Skills Score	2.00	4.93	3.26	0.68
Planning Skills Score	1.00	5.00	3.65	0.91
Risk Management Index	1.63	4.88	2.58	0.56

Source: Survey analysis (2024)

Farming experience ranged widely up to 47 years (average 12.5 years), a pattern echoed globally (e.g., Bhunu and Kwaramba 2022 in Zimbabwe; Araya et al. 2023 in Malawi), urging policies that support all farmer levels while encouraging youth participation in agribusiness. Average land size was 3.47 hectares (range nearly 37 hectares), underscoring variability best addressed via ordinal regression models like this study's; transformed farm management skills averaged 1-5 on the Likert scale.

### Model diagnostics

Table 4 displays the model fit summary, goodness of fit statistics, parallel lines test outcomes, and ordinal logistic regression analysis results. A primary constraint of the ordinal regression approach is that unmeasured variables may affect macadamia nut productivity and introduce bias into the model's conclusions. Important unaccounted factors include farm-level specifics such as soil composition and tree condition, as well as comprehensive credit and capital access data. Excluding these influential variables means the reported impacts of measured

factors such as infrastructure and market linkages on productivity could be overestimated or underestimated due to omitted variable bias. Consequently, the analysis cannot provide a complete causal account of all productivity variations observed.

Testing the model's assumptions was crucial for establishing both its robustness and practical applicability to macadamia farmers in Zimbabwe's Chipinge District. The model fit information provides sufficient statistical evidence of good fit ( $p < 0.05$ ), demonstrating that the independent variables included in the ordinal regression are collectively meaningful and effectively capture the data's underlying patterns. These results indicate the model's predictions substantially outperform chance, enhancing confidence in the findings. Therefore, the estimated coefficients can be trusted to accurately represent genuine relationships between the measured value chain factors including infrastructure and market linkages and macadamia

nut productivity within this study context.

The parallel lines test reveals no violation of assumptions ( $p > 0.05$ ), confirming the statistical appropriateness of the model. The Nagelkerke statistic indicates that 43.9% of the variance in the dependent variable is explained by the model. In practical terms, this demonstrates that the model has identified significant, actionable intervention points, enabling policymakers and development organizations to confidently prioritize these factors when designing programs. This quantified relationship provides substantial justification for targeting investments toward the model's significant predictors, thereby minimizing investor risk while offering farmers clear direction on which structural and institutional factors to address for productivity improvement. The ordinal regression model analysis results appear in Table 4 below.

**Table 4. Results from the ordinal regression analysis with parameter estimates**

Variables		Estimate	Std. Error	Sig.	Odds Ratio (OR)	Sig.
<b>Threshold</b>	[Productivity = 1.00]	3.809	0.198	0.198	45.121	0.181
	[Productivity = 2.00]	5.855	0.059	0.059***	348.972	0.052
<b>Location</b>	Age	-0.039	0.339	0.339	0.962	0.370
	Total land size	-0.076	0.280	0.280	0.927	0.274
	Experience	0.184	0.029	0.029**	1.202	0.030**
	Labour index	0.417	0.029	0.029**	1.517	0.029**
	PSS	-0.172	0.792	0.792	0.842	0.792
	TSS	1.631	0.078	0.078***	0.377	0.258
	FRS	2.407	0.025	0.025**	11.102	0.023**
	RMS	-0.574	0.564	0.564	0.061	0.044**
	PAS	1.243	0.248	0.248	3.464	0.249
	FMS	-0.975	0.251	0.251	5.107	0.066***
BMS	-2.803	0.050	0.050**	0.563	0.565	
<b>Test of parallel lines</b>						
<b>Model</b>	-2 Log Likelihood		Chi-Square		df	Sig.
<b>Null Hypothesis</b>	61.102					
<b>General</b>	52.525		8.577		11	0.661
<b>Model fitting information</b>						
<b>Model</b>	-2 Log Likelihood		Chi-Square		df	Sig.
<b>Intercept only</b>	81.741					
<b>Final</b>	61.102		20.639		11	0.037
<b>Goodness-of-fit</b>						
			Chi-Square		df	Sig.
<b>Pearson</b>			70.409		77	0.689
<b>Deviance</b>			61.102		77	0.908
<b>Pseudo R-Square</b>						
<b>Cox and Snell</b>					0.368	
<b>Nagelkerke</b>					0.439	
<b>McFadden</b>					0.252	

Notes: Link function is the Logit; \*, \*\* and \*\*\* indicate p-values significant at 1%, 5%, and 10% levels, respectively; reference category is the high productivity class [Productivity = 3.00].

Source: Survey analysis (2024)

The ordinal regression model identified five statistically significant variables ( $p < 0.05$ ) that substantially affect macadamia nut productivity, indicating that performance depends on human capital, on-farm resources, and specific structural elements working in combination. The findings demonstrate that macadamia nut productivity is fundamentally shaped by three key positive drivers namely, farm resource score (FRS), labour index, and farmer experience. FRS emerges as the strongest predictor, with a substantial Odds Ratio (OR) of 11.102 ( $p < 0.05$ ), showing that access to enhanced farm resources and capital dramatically elevates the likelihood of attaining higher productivity levels. Both labour index (OR: 1.517,  $p < 0.05$ ) and farmer experience (OR: 1.202,  $p < 0.05$ ) also demonstrate significant positive effects on performance. In contrast, business management score (BMS) exhibited a significant inverse relationship (Estimate:  $-2.803$ ,  $p = 0.050$ ), implying that existing management practices, as currently applied or assessed, are actively undermining overall productivity. Meanwhile, the technical adoption score (TSS) presents a more nuanced picture. Together, these five significant variables confirm that investments in human and physical capital represent the highest-leverage intervention opportunities, although the effectiveness of technical adoption strategies and management systems warrants urgent reassessment.

Despite clear evidence supporting productivity enhancement through targeted investment, the existing value chain exhibits pronounced financial inequity and structural barriers. Farmers retain merely 0.16% of the domestic value, while processors and agents appropriate the overwhelming majority of profits illustrated by the processor's 34.97% gross margin. This imbalance persists due to absent local processing facilities in production areas and failure to achieve international certification requirements, which constrains export potential and diminishes investment interest in productive regions. Remedying this situation demands a two-pronged strategy involving offering fiscal incentives such as tax holidays to attract local agro-processing establishments, and encouraging formal association participation (notably, 56.5% of female respondents hold membership versus 48.1% of male respondents). This strengthens collective bargaining power and market accessibility, particularly benefiting women farmers.

### **Determinants of small-scale macadamia nut productivity in Zimbabwe**

The objective was to determine the factors influencing small-scale macadamia nut productivity and identify promising leverage points for sustainable development in Zimbabwe. The study shows the need for decision-makers to understand how the different farm management competencies factors affect productivity while acknowledging the need to continuously review the resilience and risk management issues. This helps the decision makers in macadamia nuts production to design practical interventions to tackle the farm management challenges related to their skills in sourcing for resources, reducing risks while harnessing the opportunities that exist in enhancing productivity in competitive macadamia nuts business (Mokwite, 2022). Decision makers must adopt diverse farm management skills suitable for their farm resource endowments, especially regard-

ing labour and the decision maker's experience in dealing with the aforementioned challenges and opportunities. Several factors are discussed in this subsection in relation to how they affect productivity.

### **Macadamia nuts farming experience**

Farming experience emerged as the strongest positive predictor of productivity. For every additional year of macadamia farming experience, the log odds of achieving higher productivity increase by 0.184 (18.4%), holding other factors constant. This translates to a 20.2% increase in the odds ratio of moving to a higher productivity category. Experienced farmers exhibit superior skills in pest and disease management by recognizing symptoms early and applying targeted interventions, as well as in optimizing input timing to apply fertilizers and chemicals during critical windows. They also excel in quality management through practices that boost kernel recovery and meet export standards, and in navigating markets by forging relationships with reliable buyers and strategically timing sales.

These findings align with Bouarakia et al. (2023) and Scheepers (2018), who observed that macadamia farmers with more experience effectively navigate production challenges without compromising business operations. However, the complexity of the experience variable emerges when farmers over-rely on past practices, potentially inhibiting innovation adoption (Weier et al., 2024). From a policy implication perspective, extension programs should emphasize experiential learning through farmer field schools, demonstration plots, and mentorship programs pairing experienced and novice farmers. However, continuous learning must be encouraged to prevent experience from becoming a barrier to innovation adoption.

### **Index labour availability**

Labour availability significantly increases productivity ( $p < 0.05$ ). As indexed effective labour increases by one unit, the log odds of achieving higher productivity increase by 0.143 (14.3%). The odds ratio of 1.154 indicates that farmers with adequate labour are 15.4% more likely to achieve higher productivity categories.

Macadamia production is labour-intensive during pruning (January-March), which requires skilled labour to maintain tree structure and optimize fruiting, and during harvesting (March-September), demanding timely collection to prevent quality deterioration. Post-harvest processing further intensifies labour needs, as dehusking and drying demand careful handling to meet quality standards.

The positive labour effect confirms findings by Maina (2020) and Costa et al. (2020) regarding the importance of adequate labour even in technology-intensive systems. However, the challenge remains balancing labour costs with productivity gains, particularly as rural wage rates increase. Policies should support labour-saving technologies appropriate for smallholder contexts while investing in labour skill development. Community-based labour-sharing arrangements and mechanization of non-skilled operations (like dehusking) could optimize labour deployment during critical periods.

### **Farm resilience score**

Farm Resilience Score demonstrates the second-strongest positive effect on productivity ( $p < 0.01$ ). For every unit increase in FRS, the log odds of achieving higher productivity increased by 0.267 (26.7%). The odds ratio of 1.306 indicates that farmers with higher resilience scores are 30.6% more likely to achieve higher productivity. The FRS captured three key dimensions in macadamia farming: innovations reducing field losses through improved pest and disease management, mulching, and irrigation. It also highlighted climate adaptation strategies like drought-resistant practices and shade management, alongside market access improvements via diversified buyers, contract arrangements, and quality premiums.

For smallholders producing macadamia nuts, building resilience involves direct sales to high-end markets like supermarkets and restaurants that offer competitive prices for quality nuts. It also requires contract farming arrangements for input access and price stability, plus cooperative membership to enable collective investments in processing and marketing infrastructure.

These findings align with Bhunu and Kwaramba (2022) and Zuza et al. (2023), who documented strong relationships between business resilience and productivity. However, scale matters as shown by Mhlanga et al. (2020) who observed that large-scale farmers benefit more from resilience investments due to better access to ICT, finance, and early warning systems.

Government and development partners should prioritize investments in farmer resilience (Chisoro et al. (2023)). This should be achieved through three interconnected pillars including subsidized access to climate-smart technologies, facilitation of contract farming arrangements with equitable terms, and development of domestic high-value markets to reduce transaction costs compared to export markets.

#### **Indexed financial management skills score**

Contrary to theoretical expectations, Financial Management Skills (FMS) exhibited a significant negative effect on productivity ( $p < 0.05$ ). For every unit increase in FMS, the log odds of achieving higher productivity decrease by 0.118 (11.8%). The odds ratio of 0.889 indicates that farmers with higher FMS are 11.1% less likely to achieve higher productivity.

This counterintuitive finding reveals a "formalization penalty" in Zimbabwe's macadamia value chain amid severe market failure, where theoretical benefits of robust financial management such as optimizing capital allocation, maintaining detailed records, strategic investment planning, and effective cash flow management are outweighed by harsh realities. Overhead costs from time-intensive record-keeping yield no proportional returns, sophisticated planning fails against price volatility, delayed payments, and credit scarcity, liquidity constraints expose capital gaps without solutions, and transaction cost barriers block profitable opportunities despite clear financial analysis.

The finding aligns with Bouarakia et al. (2023), who observed that financial management skills among smallholder macadamia farmers are too narrow to drive productivity in contexts of resource poverty. Chingarande et al. (2020) similarly noted that formal management systems require enabling market

structures to function effectively.

Critical interpretation shows that the FRS variable (which is highly significant and positive) represents access to hard capital which facilitates actual resources and market linkages. FMS represents management sophistication, which is the ability to plan and allocate resources. In this system, access to resources (FRS) is the binding constraint, rendering sophisticated management capabilities (FMS) ineffective until market structure and capital access are fundamentally improved.

Before investing in financial management training, policy-makers must address underlying market failures while focusing on reducing transaction costs through improved infrastructure and buyer aggregation, establishing reliable payment systems to reduce liquidity risk, and developing accessible agricultural credit products. Attention must also be paid to stabilize prices through market information systems and contract enforcement. Only after these structural reforms will financial management skills translate into productivity gains.

#### **Indexed risk management skills score**

Risk Management Skills (RMS) also exhibited a significant negative effect on productivity ( $p < 0.05$ ). For every unit increase in RMS, the log odds of achieving higher productivity decrease by 0.156 (15.6%). The odds ratio of 0.856 indicates that farmers with higher RMS are 14.4% less likely to achieve higher productivity. This finding suggests three important aspects:

- a) Current risk management strategies are misaligned with actual risk profiles: Farmers' risk management approaches may focus on diversification (reducing specialization in macadamia) or conservative input use (underinvesting in productivity-enhancing inputs) rather than strategies that directly enhance macadamia productivity (Araya et al., 2023).
- b) The dynamic risk environment exceeds management capacity: Macadamia production faces multidimensional risks (price volatility, pest outbreaks, climate variability, payment defaults) that overwhelm farmers' risk management capabilities, leading to risk-averse behaviors that constrain productivity (de Medeiros and Trebat (2017).
- c) Formal risk management creates overhead without proportional benefits: Similar to FMS, sophisticated risk assessment and mitigation planning incur time and cognitive costs without yielding productivity gains in the absence of actual risk management tools (insurance, forward contracts, stabilization mechanisms).

Araya et al. (2023) noted similar concerns about the adequacy of risk management strategies in dynamic agricultural systems. Abid et al. (2020) specifically warned that contract farming which is often promoted as a risk mitigation tool can lock farmers into unfavourable arrangements that increase vulnerability rather than reducing it.

From policy implication viewpoint, risk management capacity building must be paired with actual risk management instruments including index-based insurance products covering climate and price risks, enforceable forward contracts with price floors, collective risk-sharing mechanisms through

cooperatives, and price stabilization funds managed by farmer organizations. Additionally, risk management training should emphasize productive risk-taking (investing in quality improvements, forming buyer relationships) rather than defensive strategies (diversification away from macadamia, underinvestment in inputs).

## CONCLUSION

This study determined factors influencing macadamia nut productivity among smallholder farmers in Zimbabwe using ordinal regression analysis of data from 284 farmers. Five key conclusions emerge:

a) First, farming experience is the strongest positive productivity determinant, with each additional year of experience increasing the odds of achieving higher productivity by 20.2%. Experiential learning enables farmers to navigate production challenges, optimize input timing, manage quality, and build market relationships effectively.

b) Second, labour availability significantly enhances productivity, particularly during labour-intensive operations like pruning and harvesting. Adequate, skilled labour is essential even in technology-intensive production systems to maintain quality standards required by export markets.

c) Third, farm resilience capturing innovations that reduce losses, climate adaptation strategies, and market access improvements, strongly predicts productivity. Farmers who invest in resilience-building achieve 30.6% higher odds of reaching higher productivity categories.

d) Fourth, financial management skills exhibit an unexpected negative effect on productivity, suggesting a "formalization penalty" where sophisticated management systems incur overhead costs without yielding proportional returns in contexts of severe market failure, price volatility, and liquidity constraints. Access to actual resources (captured by Farm Resilience Score) is the binding constraint, rendering management sophistication ineffective until market structures are fundamentally improved.

e) Fifth, risk management skills similarly show negative effects, indicating that current risk management strategies are misaligned with actual risk profiles or that the dynamic risk environment exceeds farmers' management capacity without actual risk management instruments (insurance, forward contracts, stabilization mechanisms).

An overarching conclusion is also made showing that, while farm experience, labour capacity, and resilience-building investments enhance productivity, the effectiveness of formal management skills (financial, risk management) is fundamentally constrained by market structure failures. In the macadamia value chain, sophisticated management cannot overcome problems of information asymmetry, transaction costs, limited credit access, and weak governance in buyer-farmer relationships. This suggests that policy interventions must address underlying market failures before investing heavily in management capacity building.

### Policy Recommendations

Based on findings, the following policy recommendations

are proposed:

a) Strengthen experiential learning systems: Establish farmer field schools, demonstration plots, and mentorship programs pairing experienced macadamia farmers with novices to accelerate knowledge transfer, as experience boosts productivity by 18.4% annually and enables rapid mastery of production and marketing skills. Extension services should shift from workshops to hands-on, learning-by-doing methods using model farms as training centers.

b) Develop labour skills and optimize deployment: Invest in labour skill development via targeted training in pruning, harvesting, and post-harvest handling, while facilitating community-based labour-sharing arrangements. Labour availability boosts productivity odds by 15.4%, yet skilled labour shortages persist during peaks; implementation involves specialized short courses at agricultural institutes and cooperative labour registries to match needs with workers.

c) Scale up farm resilience investments: Provide subsidized access to resilience-enhancing technologies like irrigation, pest management, and climate-smart practices, while facilitating equitable contract farming arrangements. Farm resilience drives 30.6% higher productivity odds, so smallholders need support for innovations, climate adaptation, and market links; implementation includes a government-backed Farm Resilience Fund for matching grants and extension-promoted transparent contracts.

d) Address market structure failures before management training: Before financial and risk management training, prioritize market structure reforms to cut transaction costs via improved rural infrastructure (roads, storage), buyer aggregation points, and mobile money for swift payments. The farmers union should support the establishment of a multi-stakeholder Macadamia Market Development Task Force comprising government, private buyers, farmer organizations, and financial institutions to design and implement coordinated market structure reforms over a 3-5 year period.

e) Develop domestic high-value markets: Facilitate direct linkages between smallholder farmers and domestic high-value buyers like supermarkets, restaurants, and hotels that pay competitive prices for quality nuts. Domestic sales cut transaction costs versus exports while matching returns, offering smallholders value capture; implementation includes buyer-farmer matching events, fair contract support, quality certification, and marketing campaigns to boost consumption.

f) Promote cooperation and strengthening of networks: Support formation of professionally managed farmer cooperation platforms, building capacity in collective marketing, input procurement, and member services. Cooperatives shall be an effective model since they aggregate volume to lower transaction costs, secure better prices, access group credit, and fund shared infrastructure unaffordable for individuals. Further, their implementation offers technical assistance, seed funding, buyer/finance links, governance training, and peer exchanges with successful experiences drawn from Kenyan and South African models and adapted to the Zimbabwean context.

### Limitations and areas for further studies

Several limitations should be acknowledged. First, the study's cross-sectional design captures associations but cannot definitively establish causation. Longitudinal studies tracking farmers over multiple seasons could strengthen causal inference. Second, geographic scope is limited to Chipinge District. National surveys would enhance generalizability and enable regional comparisons. Third, productivity was farmer-reported rather than measured directly, introducing potential recall bias despite triangulation with secondary data. Future research should:

1. Conduct longitudinal studies tracking how productivity determinants evolve as farmers gain experience and as market conditions change.

2. Expand geographic scope through national surveys enabling regional comparisons and identification of context-specific productivity drivers.

3. Investigate mechanisms through which experience translates into higher productivity using detailed time-use studies and decision-making analysis.

4. Develop and test interventions addressing market structure failures, evaluating their impact on both market functioning and the effectiveness of management skills.

5. Examine gender dimensions of productivity determinants, particularly regarding labour availability, resource access, and decision-making authority.

6. Analyze the "formalization penalty" more deeply through comparative studies of farmers at different levels of management sophistication operating in varying market contexts.

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# CYBER MATURITY AMONG EUROPEAN SMES: A TIME-SERIES AND CLUSTER-BASED ANALYSIS

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**Abstract:** *This study examines the macro-level evolution of cybersecurity maturity among European small and medium-sized enterprises (SMEs) between 2015 and 2025, with particular focus on trends in cyber threat exposure, defensive investment patterns, and the regulatory impact of the NIS2 Directive. Given the limited availability of long-term firm-level microdata, the research combines aggregated EU-level time-series data (Eurostat, ENISA, IBM) with a calibrated synthetic SME dataset (N = 100) to model maturity dynamics. Time-series forecasting was conducted using Prophet models to analyze the development of incident frequency (INCID\_FREQ) and cybersecurity investment intensity (SPEND\_RATIO), treating NIS2 as an exogenous regulatory shock. In parallel, K-Means clustering was applied across three maturity dimensions (investment ratio, NIS2 compliance level, and incident response time) to identify distinct cybersecurity profiles. The results indicate that cyber threat exposure has increased at a faster pace than defensive expenditures, particularly between 2015 and 2020. While the anticipated NIS2 effect in 2025 generates a measurable surge in security spending, it does not ensure long-term convergence between risk growth and investment intensity. The cluster analysis identifies three maturity groups (Ad-hoc, Managed, and Optimized) corresponding to consolidated CMMI and NIST-CSF levels. These findings suggest that regulatory pressure can accelerate short-term adaptation, but sustainable cybersecurity maturity among SMEs requires structural capability development, governance improvements, and strategic investment alignment*

**Keywords:** *Cybersecurity; SMEs; Cyber attacks; Digital security*  
(JEL code: M15, O33, D22, O38)

## INTRODUCTION

The exponential growth of the digital economy over the past decade has fundamentally transformed the operational logic and value-creation mechanisms of European enterprises. The technological advancements of the Fourth Industrial Revolution (Industry 4.0), including cloud computing, Big Data analytics, and the integration of artificial intelligence (AI), no longer merely provide a competitive advantage but have become a prerequisite for market participation.

At the same time, however, the spread of technological innovation and data-driven business models has dramatically increased organizations' exposure to cyber threats. (Eurofound and Cedefop, 2025) As a recent OECD analysis highlights, the importance of cybersecurity protection is steadily increasing as digital technologies become deeply embedded in critical sectors of the economy; in parallel, both the frequency of cyberattacks and the costs of disruptions are rising. As emphasized by the research of Seed et al. (2023), the strategic significance of cybersecurity continues to grow, and corporate value creation is now inseparable from information security maturity.

An examination of the structure of the European econo-

my reveals that small and medium-sized enterprises (SMEs) constitute its backbone. According to Eurostat (2024), more than 99% of enterprises in the European Union belong to this sector, providing nearly two-thirds of total employment and generating a substantial share of added value.

Consequently, the cyber resilience of the SME sector is not merely a firm-level risk management issue but also a factor of macroeconomic stability. The sector faces a dual challenge: digital transformation is unavoidable in order to maintain market competitiveness, yet most enterprises operate with limited financial and human resources to develop and sustain advanced cybersecurity solutions. (Yigit Ozkan, B., & Spruit, M., 2022)

While multinational corporations and operators of critical infrastructure have progressively developed sophisticated, multi-layered defense mechanisms (defense-in-depth), the SME sector lags significantly behind in terms of cybersecurity maturity. Numerous studies indicate that SMEs typically lack adequately trained professionals, documented processes, and dedicated IT budgets, resulting in a security gap compared to large enterprises. (Heidt et al., 2019)

This "security gap" generates asymmetric risk: attackers increasingly target less protected SMEs, often using them as

entry points for supply chain attacks against larger corporations. (Elena Kaiser, 2023)

Despite the outstanding economic importance of SMEs, measuring the sector's cyber resilience faces structural challenges, particularly with regard to time-series data. While systematic data are available for large-scale operators of essential services (OES), statistical data collection within the SME sector remains fragmented and incomplete.

The study seeks to answer the following research questions:

1. How did trends in cybersecurity threat exposure and defensive expenditures evolve among European SMEs between 2015 and 2025?
2. What impact has the NIS2 Directive had on the development of cybersecurity among European SMEs?
3. Can clearly distinct maturity clusters be identified among SMEs, and how can these be characterized?

## LITERATURE REVIEW

### SMEs and Cybersecurity Challenges

European small and medium-sized enterprises (SMEs) continue to operate in a complex economic environment. In recent years, geopolitical tensions, particularly the Russian–Ukrainian war, high energy prices, inflation, and disruptions in supply chains have significantly affected their operations. Global economic prospects remain uncertain, while international trade tensions and changes in tariff regimes pose additional downside risks (European Commission, 2024).

Despite these adverse conditions, SMEs continue to play a decisive role in the EU economy. In 2024, approximately 26.1 million enterprises operated in the non-financial business sector, with projected growth of 1.2% by 2025 (European Commission, 2024). Microenterprises are particularly dynamic: their real value added is expected to increase by 2.2% by 2025, indicating that the sector retains a certain degree of adaptive capacity.

**Table 1. Economic structure of enterprises by size class in the EU, 2024**

Class size	Number of enterprises	Share (%)	Persons employed	Share (%)	Real Value Added (Billion €)	Share (%)
Micro	24,514,649	93.6%	41,540,252	30.1%	1,538	20.1%
Small	1,404,631	5.4%	26,889,824	19.5%	1,273	16.6%
Medium-sized	214,000	0.8%	21,358,947	15.5%	1,293	16.9%
<b>SMEs (total)</b>	<b>26,133,280</b>	<b>99.8%</b>	<b>89,789,023</b>	<b>65.1%</b>	<b>4,104</b>	<b>53.6%</b>
Large	44,358	0.2%	48,039,714	34.9%	3,559	46.4%
<b>Total</b>	<b>26,177,638</b>	<b>100%</b>	<b>137,828,737</b>	<b>100%</b>	<b>7,663</b>	<b>100%</b>

*Source: JRC calculations based on Eurostat's Structural Business Statistics, Short-Term Business Statistics, and National Accounts Database*

This resilience, however, is grounded not only in financial and organizational capacity but also in digital preparedness and cybersecurity readiness. More than half of SMEs lack a formal cybersecurity plan or dedicated specialist (ENISA SME Survey, 2022), while the proportion of cyberattacks continues to increase year by year.

At this point, the concept of cyber resilience becomes central: it encompasses not only prevention but also rapid recovery following attacks and the systematic incorporation of lessons learned.

The IBM Cost of a Data Breach Report 2024 highlights that post-incident recovery is a lengthy and complex process for most organizations. According to the report, only 12% of affected organizations reported full recovery. Among surveyed companies, 78% required more than 100 days to recover, while more than one-third needed over 150 days to achieve full restoration (IBM, Cost of a Data Breach Report, 2024). The term “recovery time” in the report does not refer solely to the technical restoration of IT systems but to the broader organizational regeneration process, including the settlement of fines and compensation, as well as the fulfill-

ment of compliance obligations.

An organization's cyber resilience is closely linked to its cybersecurity maturity, which reflects the extent to which risks are managed consciously and systematically. Prominent maturity models, such as CMMI, the NIST Cybersecurity Framework (NIST CSF), ISO/IEC 27001, and the ENISA SME Assessment Tool, share the common premise that cybersecurity constitutes a developable organizational capability across technological infrastructure, governance processes, human factors, and incident response. Enhancing cybersecurity maturity is therefore a fundamental prerequisite for the sustainable digital transformation of SMEs.

### AI-Driven Attacks and the Risk of Shadow AI

In recent years, a clear trend has emerged: artificial intelligence (AI) not only strengthens defensive mechanisms, through faster detection and response capabilities, but has also become embedded in attackers' toolkits. Certain analyses indicate that the application of cybersecurity automation and AI can significantly reduce the scale of damages. According to IBM's 2025 data, organizations extensively using AI and automation experienced, on average, USD 1.9 million

lower incident costs, and the lifecycle of a cyberattack (from detection to containment) was shortened by 80 days.

At the same time, AI has become an effective weapon in the hands of adversaries. IBM's 2025 report notes that in 16% of the analyzed data breaches, attackers employed some form of AI tool, most commonly for phishing purposes.

For SMEs, a particularly critical risk is so-called Shadow AI, that is, the use of unauthorized AI tools operating outside formal organizational oversight. According to IBM data, incidents linked to Shadow AI accounted for 20% of all data breaches. This risk is further amplified by the fact that 63% of organizations either lack a formal AI governance policy or are only in the process of developing one.

These findings underscore that, in the future, SMEs must not only strengthen traditional IT security practices but also address the security implications of AI adoption and governance in a systematic manner (IBM Newsroom, 2025).

### European Policy and Regulatory Environment

The European Union has recognized that enhancing cybersecurity maturity is essential for the competitiveness and resilience of the digital economy. The NIS2 Directive was adopted by the European Union in December 2022 and entered into force on 16 January 2023, while Member States were required to transpose the directive into national law by 17 October 2024. The directive mandates that each Member State adopt a national cybersecurity strategy, including provisions on supply chain security, vulnerability management, as well as education and awareness-raising programs. Compared to the previous NIS1 framework, the new directive introduces a broader scope, clearer regulatory requirements, and stricter supervisory and enforcement mechanisms.

**Sectoral extension:** In addition to previously covered critical infrastructures (energy, transport, finance, healthcare, drinking water, and digital infrastructure), the directive now also encompasses public electronic communications, digital services (e.g., online marketplaces and social platforms), waste management, critical product manufacturing, postal and courier services, central and regional public administration, and even the space sector.

**Extension by size:** As a general rule, NIS2 obliges all medium-sized and large entities operating in critical sectors to implement appropriate cyber risk management measures and to report any significant incidents to the competent authority.

In parallel, the EU has launched programs such as the Digital Europe Programme (2021–2027) and the Digital Decade 2030 initiative, which support the widespread adoption of digital technologies, including cybersecurity and artificial intelligence. Within these frameworks, SMEs receive particular emphasis through targeted funding instruments and expert support structures, such as the European Digital Innovation Hubs, to facilitate cybersecurity development.

The overarching objective is to ensure that SMEs do not merely react to evolving threats but proactively integrate into the broader digital and security ecosystem. Consequently, cybersecurity maturity is no longer solely a defensive factor but is increasingly becoming a prerequisite for competitiveness in the digital economy.

### NIS2 as an Exogenous Shock

The NIS2 Directive clearly constitutes an external shock to the SME sector, exerting a coercive effect on security investments in certain respects. Its predecessor was the NIS1 Directive adopted by the European Union in 2016, which primarily focused on critical infrastructure and operators of essential services, leaving the majority of SMEs outside its direct scope. However, the acceleration of digitalization and the growing vulnerability of supply chains exposed the limitations of this framework, ultimately leading to the adoption of NIS2.

With its expanded scope and more stringent requirements, NIS2 represents a tangible exogenous shock for the SME sector. The new regulation introduces strict compliance and incident-reporting obligations, including notification to the competent authority within 72 hours of a significant incident, the requirement to conduct independent cybersecurity audits every two years, and the provision of continuous employee training (EU NIS, 2022). These obligations, along with the prospect of substantial fines for non-compliance, constitute primary incentives for SMEs to increase cybersecurity expenditures.

Importantly, NIS2 is not merely a legal obligation; in practice, it is increasingly becoming a prerequisite for entering or remaining within supply chains. Large enterprises falling under the scope of NIS2 (so-called essential and important entities) are responsible for the security of their entire supply chains and therefore expect compliance from their SME partners, often in the form of security audits. This market-driven pressure represents an indirect yet indispensable driver of cybersecurity maturity growth.

It is already observable that consulting firms are approached by companies that, while not directly subject to NIS2, serve as suppliers to large enterprises that are. (RealCob, 2025). These major partners seek to assess their subcontractors' cybersecurity posture or require formal declarations of compliance with NIS2 requirements. For suppliers, the outcomes of such audits are critical, as they may directly affect future business opportunities, including tenders and contractual engagements. Thus, even where legal compliance with NIS2 is not yet mandatory, competitive pressure and the need to maintain cooperation with larger partners compel SMEs to implement security improvements and standardize their systems.

Overall, the cybersecurity maturity of SMEs is shaped by a complex set of factors: internal resources and awareness levels, rapidly evolving threat landscapes (e.g., AI-driven attacks), as well as the regulatory and market environment all exert significant influence.

Based on the review of theoretical models and the relevant literature, it is evident that the cybersecurity maturity of SMEs is influenced by a range of interrelated factors, from technological advancement and regulatory pressure to organizational awareness. At the same time, publicly available, long-term micro-level data suitable for quantitative analysis are typically lacking, particularly with a specific focus on the SME segment.

To address this limitation, the present study employs syn-

thetic indicators calibrated to reflect real-world trends in order to map the temporal evolution of cybersecurity maturity and its principal determinants. The methodology presented in the following section aims to explore SMEs' security investment patterns, resilience characteristics, and the potential impact of the NIS2 regulation through statistical modeling.

## MATERIALS AND METHODS

This study applies a predominantly quantitative research design. The qualitative elements are limited to the conceptual interpretation of cybersecurity maturity frameworks and policy implications related to NIS2.

### Data Sources and Time Interval

The objective of this study is to explore macro-level changes in the cybersecurity environment of European small and medium-sized enterprises (SMEs), with particular emphasis on the evolution of security investments, trends in incident frequency, and the potential impact of the regulatory environment, primarily the NIS2 Directive, over the 2015-2025 period.

The quantitative analysis is constrained by the lack of publicly available, long-term, firm-level microdata on cybersecurity maturity within the EU SME sector. To address this limitation, the study employs proxy indicators derived from consolidated macro-level data sources, along with a calibrated synthetic firm-level dataset. The proxy-based approach was adopted because harmonized, long-term, firm-level cybersecurity maturity data for European SMEs are not publicly available. The purpose of the synthetic dataset is not to precisely replicate the actual SME population, but rather to generate plausible distributions suitable for the statistical identification and comparison of cybersecurity maturity clusters.

The synthetic database represents  $N = 100$  European SMEs, each assigned an EU Member State country code and an economic sector classification. The sample includes ten sectors commonly represented among SMEs (e.g., manufacturing, ICT services, financial services, healthcare, trade, logistics). During data generation, firms were constructed from three sampling segments reflecting different cybersecurity maturity levels (low, medium, and high maturity), in approximately 40-40-20% proportions. These proportions served solely for calibration purposes and were not directly imposed on the clustering algorithm; maturity clusters were determined in a fully data-driven manner based on the input variables using the K-Means algorithm.

The dataset operationalizes three key dimensions of cybersecurity maturity:

- SPEND\_RATIO - the proportion of information security expenditures within the total IT budget (%),
- NIS2\_COMP - the estimated proportion of implemented mandatory measures associated with the NIS2 Directive (%),
- INCID\_TIME - the time required to detect and contain cybersecurity incidents (days).

### Theoretical Justification of Maturity Variables

Cybersecurity maturity is a multidimensional organizational capability that encompasses technological preparedness, governance structures, incident response capacity, and continuous improvement mechanisms. In order to operationalize these dimensions within the SME context, the present study applies three proxy variables derived from established cybersecurity maturity frameworks, primarily the NIST Cybersecurity Framework (NIST CSF) and the Capability Maturity Model Integration (CMMI).

The variable SPEND\_RATIO, representing the proportion of cybersecurity expenditures within the total IT budget, serves as an indicator of technological and organizational capability development. Previous studies suggest that cybersecurity investment intensity reflects the extent to which organizations prioritize security capacity-building, infrastructure modernization, and preventive controls (Heidt et al., 2019; ENISA, 2024). Within the logic of the NIST CSF, this variable is primarily associated with the Protect function, while in the CMMI framework it reflects the transition from ad hoc security practices toward more managed and optimized processes.

The variable NIS2\_COMP captures the estimated level of implementation of mandatory cybersecurity measures associated with the NIS2 Directive. This variable reflects governance maturity, regulatory preparedness, and the formalization of cybersecurity processes. In conceptual terms, it corresponds to the Identify and Govern dimensions of cybersecurity management within the NIST CSF logic, including risk assessment, policy implementation, and compliance monitoring. From a CMMI perspective, higher levels of NIS2 compliance indicate increasing process formalization and institutionalization.

The variable INCID\_TIME, measuring the time required to detect and contain cybersecurity incidents, represents organizational resilience and operational response capability. Incident response speed is widely recognized as a critical dimension of cybersecurity effectiveness, particularly in relation to business continuity and recovery performance (IBM Security, 2024). Within the NIST CSF framework, this variable is linked to the Detect, Respond, and Recover functions, while in the CMMI maturity logic it reflects the degree to which organizations possess repeatable and optimized incident management processes.

Taken together, these three variables provide a multidimensional approximation of SME cybersecurity maturity by integrating technological capability (SPEND\_RATIO), governance and compliance readiness (NIS2\_COMP), and operational resilience (INCID\_TIME). Although the study relies on proxy indicators and synthetic firm-level data, the selected variables are conceptually grounded in established cybersecurity maturity frameworks and calibrated using empirically observed distributions reported by ENISA, IBM, and related European cybersecurity studies.

### Variable Calibration and Data Construction

The variables were sampled from differently parameterized distributions to ensure realistic heterogeneity aligned

with varying SME cybersecurity maturity levels. However, cluster determination relied exclusively on the results of the data-driven K-Means algorithm. Parameter ranges were calibrated based on ENISA NIS Investments reports (investment ratios and dispersion), ENISA NIS implementation experience and preparedness surveys (NIS2 compliance), and IBM Cost of a Data Breach reports (scaled components of incident detection and response times).

The SPEND\_RATIO variable measures the share of information security expenditure within the total IT budget (%),

with its distribution calibrated to EU median values reported by ENISA (approximately 5-13%) and the broader variance observed among SMEs.

The resulting dataset served as the basis for cybersecurity maturity cluster analysis, while the time-series analyses rely exclusively on actual macro-level data from Eurostat, ENISA, and IBM

The synthetic dataset does not aim to reproduce the actual SME population, but to approximate plausible maturity distributions based on published aggregate indicators.

**Table 2. Operationalization of Variables Using a Proxy Approach**

Category	Variable (Proxy)	Operationalization (Measurement)	Objective within the Maturity Model
<b>Cybersecurity Maturity (CYB_MAT)</b>	CYB_CLASS (Cluster Variable)	1, 2, 3 (cybersecurity maturity profiles identified through data-driven K-Means cluster analysis)	Process, Capability dimension
<b>Investment Capacity</b>	SPEND_RATIO	Share of cybersecurity expenditures relative to total IT spending (estimated ratios based on ENISA and IBM data)	Technological, Capability dimension
<b>Risk Exposure</b>	INCID_FREQ (Time Series)	Annual Incident Frequency Index (primarily ransomware and phishing incidents)	Resilience, Detection dimension
<b>NIS2 Compliance</b>	NIS2_COMP	Estimated proportion of implementation of the 10 mandatory NIS2 measures (%)	Organizational, Process dimension

Source: Author's own compilation

### Statistical Modeling

The objective of the time-series analysis is to dynamically examine trends in cybersecurity investments and threat exposure among SMEs over the 2015–2025 period. The analysis employs the Prophet model to identify temporal patterns, long-term trends, and potential structural breakpoints. The introduction of the NIS2 Directive is treated as an external (exogenous) event that may influence the evolution of variables representing cybersecurity maturity.

The model is based on two primary indicators:

- INCID\_FREQ: the annual percentage of SMEs reporting at least one significant ICT security incident (including ransomware, phishing, and DDoS events), based on aggregated Eurostat and ENISA data;
- SPEND\_RATIO: the proportion of cybersecurity investments within total IT expenditure (Eurostat).

The dataset covers the period from 2015 to 2024, with the model generating forecasts for 2025-2026.

To assess short-term forecast reliability, a one-step-ahead

rolling backtest was conducted for both time-series models. Forecast accuracy was evaluated using Mean Absolute Error (MAE), expressed in percentage points. The backtest results indicate an average absolute deviation of 1.32 percentage points for INCID\_FREQ and 1.18 percentage points for SPEND\_RATIO. Given the annual frequency and limited sample size, this error magnitude suggests a reasonably stable short-term predictive performance and supports the interpretability of the projected trends.

In order to ensure a holistic approach to cybersecurity maturity, drawing conceptually on the CMMI and NIST Cybersecurity Framework (NIST CSF), K-Means clustering was applied. K-Means was selected because it provides an interpretable unsupervised classification method for identifying homogeneous groups based on numerical cybersecurity maturity variables. The number of clusters was set to  $k = 3$  based on the three-tier maturity logic adopted in this study, informed by established cybersecurity maturity frameworks such as CMMI and NIST CSF.

The clustering procedure was conducted along three principal dimensions that collectively capture the critical components of maturity:

- SPEND\_RATIO (the proportion of security expenditures within the total IT budget),
- NIS2\_COMP (level of preparedness for NIS2 compliance), and
- INCID\_TIME (time required for incident detection and containment).

This clustering approach enables the identification of distinct SME maturity profiles based on multidimensional cybersecurity characteristics.

## RESULTS AND DISCUSSION

### Time-Series Analysis of European SME Cybersecurity Trends (2015–2025)

The time-series analysis database consists of annual-frequency, aggregated indicators at the European SME level covering the 2015–2025 period.

The analysis was based on two key indicators:

- INCID\_FREQ: The annual incidence rate of reported IT security incidents affecting small and medium-sized enterprises (SMEs) operating within the EU.
- SPEND\_RATIO: The proportion of IT security expenditures within the total corporate IT budget.

### Trend Analysis and Forecasting

The evolution of cyber threat exposure (INCID\_FREQ) was examined using a linear Prophet model, while the growth of security expenditures (SPEND\_RATIO) was modeled with a logistic curve, incorporating the expected impact of the NIS2 Directive entering into force in 2025.

Given the limited number of annual observations, the Prophet model for INCID\_FREQ was primarily applied as a trend-fitting and short-term forecasting tool.

### Key Findings

- INCID\_FREQ nearly doubled between 2015 and 2020 (from approximately 7.5% to around 15%), reaching 21.5% by 2023–2024, where it temporarily stabilized. The model estimates an incidence rate of approximately 23.7% for 2025 and 25.3% for 2026.

- SPEND\_RATIO remained at roughly 5% in 2019 but increased to a median of 9% by 2023. Due to the projected NIS2 effect in 2025, the model estimates a one-time upward shift to approximately 12%, followed by a further increase to 13.1% in 2026.

The dynamic interaction of the two indicators suggests that the growth rate of cyber threat exposure exceeds the pace of defensive investment. However, the NIS2-related regulatory effect may temporarily accelerate adaptation within the SME sector.

**Table 3. Summary Table of Time-Series Results**

Year	INCID_FREQ (% of firms affected)	SPEND_RATIO (% of IT budget)	Remarks
2015	~7.5% (model baseline)	~3–5% (low level)	Cyber threat exposure still moderate; security spending minimal
2020	~15% ( $\approx 2 \times 2015$ )	~5.5%	Sharp increase in attacks; defensive investments lag behind
2023	21.5% (actual, Eurostat / ENISA)	9.0% (actual)	High incident rate; intensified focus on cybersecurity
2024	21.54% (actual, Eurostat 2024)	~9.5% (model estimate)	Incident rate stabilizing; gradual increase in spending
2025 (expected)	23.7% (Prophet forecast)	~12.1% (NIS2-driven one-time surge)	NIS2 compliance requirements → investment wave
2026 (expected)	25.3% (Prophet forecast)	~13.1% (logistic growth)	Persistently high threat level; security investment stabilizes at a higher plateau

Source: ENISA, Eurostat, IBM, OECD, and Prophet model estimations.

### Context and Literature Background

The global economic cost of cybercrime had doubled by 2020 compared to its 2015 level, indicating that both the fre-

quency and severity of attacks were still relatively moderate in 2015 (ENISA, 2024). During this period, organizations allocated on average only 3–5% of their total IT budgets to secu-

**Table 4. Main Parameters of the Prophet Models (Time-Series Analysis)**

Parameter	INCID_FREQ Model	SPEND_RATIO Model	Explanation
Model	Prophet	Prophet	Additive time-series model with trend + (optional) components
growth	linear (default)	logistic	Linear trend for incidents; saturating growth for expenditures
Capacity	–	cap = 15.0, floor = 0.0	Logistic growth with upper bound constraint
yearly_seasonality	False	False	Yearly seasonal component disabled (annual data points)
daily_seasonality	False	False	Daily seasonal component disabled
seasonality_mode	additive (default)	additive (default)	Additive treatment of seasonal effects (if applicable)
n_changepoints	25 (default)	25 (default)	Number of automatically detected trend changepoints
changepoint_range	0.8 (default)	0.95	Proportion of the time series in which changepoints are allowed
changepoint_prior_scale	0.05 (default)	0.6	Trend flexibility (higher value → more flexible trend)
Exogenous regressor	–	nis2	NIS2 proxy regressor (2024 = 0.3; 2025–2026 = 1.0)
nis2 prior	–	prior_scale = 5.0, additive	Strength (regularization) of the regressor's effect
interval_width	0.80 (default)	0.80 (default)	Width of the forecast confidence interval

Source: Author's own compilation.

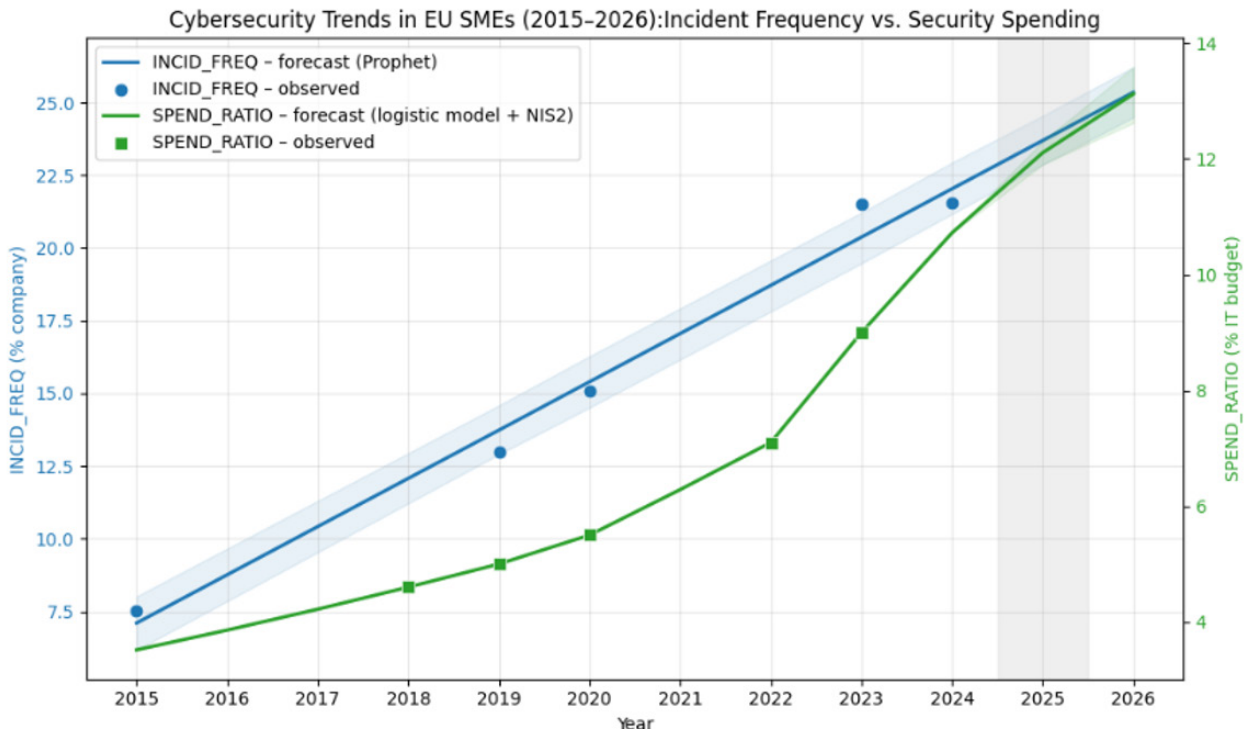
rity, meaning that defensive investments also started from a low baseline (NGA, 2019).

In Europe, by 2019 approximately 13% of enterprises had already experienced some form of ICT security incident, representing a significant increase compared to previous years (OECD, 2021). In contrast, the proportion of IT security spending rose only marginally from around 5%; in 2019 the median remained approximately 5%, and by 2020 it still hovered around 5–6% (Grillo & Dhifi, 2024). This divergence indicates that the growth in threat exposure was not matched proportionally by defensive investment.

According to the most recent data, in 2023 21.5% of EU enterprises experienced an ICT security incident, meaning that more than one in five firms were affected, representing a dramatic increase compared to the mid-2010s (Eurostat, 2023). In parallel, the share of spending dedicated to information security increased: in 2023, enterprises allocated a median of 9.0% of their IT budgets to cybersecurity (compared to approximately 7.1% in the previous year) (ENISA, 2024). Although security

expenditure grew dynamically by 2023, it still lagged behind the pace of increasing threat exposure. This discrepancy can be explained by the severe wave of cyberattacks observed in the early 2020s, including ransomware campaigns and distributed denial-of-service (DDoS) attacks.

Looking ahead, cyberattacks are expected to continue rising: 90% of organizations anticipate further increases in attacks over the coming year (ENISA, 2024). With the entry into force of the NIS2 Directive in 2024, SMEs are also subject to mandatory minimum security requirements, which is likely to result in a one-time, and partly sustained, surge in defensive spending. According to ENISA's 2024 survey, most organizations expect to require additional budget allocations to achieve NIS2 compliance. As a result, by 2025 the share of IT security expenditures is projected to exceed 10% of total IT budgets. This may mark the first year in which growth in security investment, driven by regulatory pressure, keeps pace with the rising threat landscape.

**Figure 1. Evolution and Forecast of INCID\_FREQ and SPEND\_RATIO (2015–2026)**

Source: Author's own compilation.

The above figure illustrates the temporal evolution of cybersecurity threat exposure (INCID\_FREQ) and the proportion of IT security expenditures (SPEND\_RATIO) among European SMEs over the 2015-2026 period.

Based on the figure, the following patterns can be clearly observed:

- INCID\_FREQ (threat exposure) shows a continuous upward trajectory, reaching approximately 25% by 2025-2026.
- SPEND\_RATIO initially increases at a slower pace; however, as a result of the projected NIS2 effect in 2025, a significant surge in security investment occurs, approaching the 13% level.

The convergence of the two trends suggests that regulatory pressure may temporarily narrow the gap between rising threat exposure and defensive capacity.

### Cluster Analysis of Cybersecurity Maturity Levels

K-Means clustering was performed along three key indicators that comprehensively capture cybersecurity maturity:

- SPEND\_RATIO (the proportion of security expenditures within the total IT budget),
- NIS2\_COMP (level of preparedness for NIS2 compliance), and
- INCID\_TIME (time required for incident detection and containment).

Although the EU Cybersecurity Index (EU-CSI) and related surveys published by ENISA and Eurostat provide aggregated data on the cybersecurity status of the SME sector, such as incident prevalence rates and national medians, these datasets are typically aggregated at the Member State level and

do not include publicly available firm-level microdata.

In the absence of such microdata, the present cluster analysis relies on a synthetic dataset calibrated to reflect real-world statistical distributions described in Eurostat, ENISA, and IBM reports. This approach enables SME-level cybersecurity maturity modeling while remaining aligned with empirically observed trends.

As a result, three maturity profiles emerged, consistent with the value ranges reported in published sources. The maturity levels assigned to the clusters are based on a combined interpretation of the CMMI (Capability Maturity Model Integration) and the NIST Cybersecurity Framework (CSF).

CMMI defines five maturity levels (“Initial,” “Managed,” “Defined,” “Quantitatively Managed,” and “Optimizing”), while NIST CSF distinguishes four implementation tiers (“Partial,” “Risk-Informed,” “Repeatable,” and “Adaptive”). Both frameworks follow a comparable maturity logic. In the present analysis, these were consolidated into three levels aligned with SME practice:

- Level 1: Initial / Ad hoc,
- Level 2: Repeatable / Defined,
- Level 3: Managed / Optimized.

This three-tier scale is consistent with both CMMI and NIST maturity frameworks and provides a professionally grounded basis for describing cybersecurity maturity clusters. The distributions of the indicators were calibrated to ranges reported in recent ENISA, IBM, and JNGR research, ensuring that while the dataset is statistically synthetic, it reflects realistic and empirically grounded trends.

**Table 5. Statistical Characteristics and Literature Alignment of Cybersecurity Maturity Groups Identified by K-Means Clustering**

Indicator	Distribution / Logic (by Cluster)	Source / Rationale
	Cluster I: <5%	
SPEND_RATIO	Cluster II: 5-10%	<a href="#">ENISA NIS Investments 2021–2023</a> , (median 6.7-9%, with wide dispersion among SMEs)
	Cluster III: >10%	
	Cluster I: <60%	
NIS2_COMP	Cluster II: 60-75%	<a href="#">ENISA NIS Implementation</a> (2020) + <a href="#">JNGR 2025 preparedness study</a> (48.5% vs. 72.3%)
	Cluster III: >75%	
	Cluster I: >30 days	
INCID_TIME	Cluster II: 15-30 days	<a href="#">IBM 2024</a> (258-day global average breach lifecycle, scaled proportionally to detection & response phase)
	Cluster III: <15 days	

Source: IBM, ENISA (2020)

The data-driven K-Means clustering applied to the synthetic dataset, calibrated to reflect real-world trends, identified three clearly distinguishable cybersecurity maturity profiles, which are presented in the following table.

**Figure 2. Results of K-Means Clustering Among European SMEs - Median Values by Cluster**

Median values by K-Means cluster				
cluster_kmeans	n	spend_ratio_med	nis2_comp_med	incid_time_med
1	41	7.65	71.20	22.0
2	41	4.60	53.80	38.0
3	18	12.34	90.45	11.5

Source: Author's own compilation.

**Table 6. Cybersecurity Maturity Profiles of Empirically Identified Clusters Based on Applied Maturity Models**

Cluster	Maturity Level (CMMI/ NIST)	SPEND_RATIO (IT Security / IT Budget)	NIS2_COMP	INCID_TIME (Response Time)	Brief Characterization
<b>I. Ad-hoc Protected</b>	~1 (Initial)	Low	Low–Medium	Long	Low investment, limited compliance, slow response; high exposure and disproportionate compliance burden
<b>II. Managed Processes</b>	~2–3 (Repeatable / Defined)	Medium	Medium	Medium	Documented controls, improving maturity; frequent use of MSSP, EDR, and SIEM solutions
<b>III. Optimized Resilience</b>	~4–5 (Managed / Optimized)	High	High	Short	Mature processes, automation/ AI integration, practiced incident response playbooks; rapid detection and recovery

Source: Author's own compilation.

The cluster structure presented above is consistent with observed EU-level trends: median and average security expenditures have increased in recent years (ENISA); compliance levels vary significantly across sectors and firm sizes (transition from NIS to NIS2); and incident response times are substantially shorter among more mature, automated organizations (IBM). Given the absence of harmonized, publicly available European microdata on cybersecurity maturity, particularly within the SME sector, the model relies on a synthetic dataset calibrated to reflect empirically observed trends.

## CONCLUSION

The aim of this study was to examine the macro-level cybersecurity maturity of European SMEs using synthetic data aligned with empirical trends. The research was built upon two principal methodological pillars: time-series forecasting and cluster-based maturity segmentation.

During the examined period (2015–2025), the growth of cyber threat exposure significantly outpaced the increase in defensive expenditures, particularly between 2015 and 2020. Although the NIS2 Directive, entering into force in 2024, triggered a one-time investment surge (as confirmed by the modeling results), it does not guarantee the sustained elevation of security spending levels. Nevertheless, regulatory pressure functions as a tangible incentive mechanism, demonstrably increasing IT security expenditures in quantitative terms.

The cluster analysis identified three clearly distinguishable cybersecurity maturity groups among SMEs (Ad-hoc, Managed, Optimized). These maturity tiers not only describe the heterogeneous defensive capabilities of organizations but also provide a structured basis for targeted policy interventions and support mechanisms.

In conclusion, the study demonstrates that while regulatory pressure can act as a catalyst for short-term improvements in cybersecurity spending, achieving sustained maturity requires a multifaceted approach that combines regulatory oversight with strategic investment incentives and capacity-building initiatives. The proposed maturity clusters offer a valuable tool for advancing evidence-based cybersecurity policy in the SME sector, contributing to both theoretical understanding and practical implementation.

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# THE INFLUENCE OF GOVERNANCE ON FOOD LOSS AND WASTE: A TANZANIAN PINEAPPLE VALUE CHAIN PERSPECTIVE

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**Abstract:** Food loss and waste remain a substantial challenge in agricultural value chains, particularly in developing countries. This study examines the influence of governance on food loss and waste within the pineapple value chain in Tanzania. Using qualitative methods, data were collected in Dar es Salaam, Geita, Morogoro, and Pwani regions through focus group discussions, interviews, and observations. The study mapped actors and explored the role of governance, power dynamics, and coordination, drawing on resource dependence and institutional theories to explain how actor relationships, power imbalances, and institutional influences shape food loss and waste. Three types of governance structures were revealed—spot market, captive and relational structures, affecting food loss differently. In the captive governance structure, pre-finance arrangements lock farmers into selling only to specific traders, often leading to significant on-farm losses when market conditions shift. Spot markets, on the other hand, generate losses when harvested fruits do not meet the informal standards set by buyers, such as size, ripeness, and other physical attributes, due to limited market information. Weak coordination, information asymmetry, and power imbalances among value chain actors contributed to substantial food loss and waste. Main challenges faced by farmers included poor access to markets, financial constraints, and weak bargaining power. Institutional gaps, including weak regulatory frameworks and inadequate support from government and private sector, exacerbate inefficiencies. The study emphasizes that governance plays a central role in shaping food loss and waste. Strengthening farmers' associations, improving market linkages, and addressing institutional gaps are critical for reducing food loss and waste and increasing value chain resilience.

**Keywords:** Food loss and waste, Value chain mapping, Governance, Coordination, Power dynamics  
(JEL code: Q13; L14)

## INTRODUCTION

In agricultural value chains, food loss and waste (FLW) significantly affect food security, incomes, economic growth, and environmental sustainability (FAO, 2019; Petrescu-mag et al. 2024). FLW occurs throughout the value chain, from production and post-harvest handling to processing, distribution, and consumption stages (Holland, 2021; Luo et al., 2021; Surucu-Balci and Tuna, 2022). Despite the increased focus on food loss and waste in the last decade, food is still being lost and wasted along the supply chain (Mann et al. 2020) and is influenced by different factors. Globally, it is estimated that one-third of the food produced annually gets lost or wasted along the value chain (Gustavsson et al., 2011; FAO, 2019), with fruits and vegetables accounting for 46% of the total FLW (Ekka and Mjawa, 2020). The effect of FLW is evident to smallholder farmers, particularly in developing countries. A well-structured and efficient value chain can lead to more

effective resource allocation, generating economic benefits for all actors along the value chain and reducing food losses (van der Maden et al., 2021). While coordination requires strong governance and mutual trust among actors (Trienekens 2011), poor coordination can result in significant losses, especially for perishable crops (Kitinoja et al., 2018).

Food loss and waste is experienced in developing and developed countries, and the causes involve several factors. However, FLW occurrence varies with production practices and the state of value chain development. The dynamics of interactions and power relationships among value chain actors are believed to have a significant role in FLW (Herzberg et al., 2022). Governance in a value chain is the authority and power relationships among actors that determine the flow and allocation of resources and finances within a chain (Gereffi and Fernandez-Stark 2016). In the formal mechanism, governance can increase FLW when large buyers, particularly processors and exporters, impose strict quality standards based on

shape, size, color, or delivery schedules, leaving actors liable to losses when they fail to comply (Santos de Carvalho et al., 2018). Actors are forced to endure unequal risk and cost of FLW resulting from power imbalances among actors (Cromwell et al., 2025).

The governance structure is always determined by the complexity of information shared between actors, how the information can be easily codified, and the producer's level of competence (Gereffi and Fernandez-Stark, 2016). On the other hand, governance structures determine how value chains are organized and managed, influencing compliance, quality standards, and resource allocation (Trienekens, 2011). Weak governance structures in agricultural value chains, specifically in developing countries, often fail to address systemic issues like value chain inefficiencies, which limit market linkages, financial support, and collaboration among public and private sectors, which are critical for FLW reduction (Hodges et al., 2011). Strengthening governance mechanisms can facilitate better integration of actors, fostering shared responsibility in managing FLW. An exploration of actors' influences and dynamics provide valuable insights that could inform policy and enhance value chain sustainability (Monticone et al., 2024).

Pineapples are an important horticultural crop in Tanzania, providing a vital source of income for smallholder farmers (Pesha and Mbawala, 2018). However, the pineapple value chain struggles with food loss and waste. Factors such as inadequate market information, financial constraints, and underdeveloped agricultural institutions contribute to pineapple losses (Abdalah et al., 2018; van der Maden et al., 2021). Although existing literature emphasizes chain governance and its influence on food loss and waste (Arinloye, 2013; Warsanga, 2014; Santos de Carvalho et al., 2018; Kiambi et al., 2020; Nyokabi et al., 2023; Massawe and Mwololo, 2024), there is a lack of empirical research examining the governance mechanisms affecting food loss and waste in Tanzania (Kulwijiya et al., 2018). Most literature on food loss, especially related to post-harvest losses in Tanzania, has focused on technological or infrastructural causes, with minimal studies investigating coordination, power dynamics, actor relationships, or standards and compliance (Chegere, 2018; Ahmad et al., 2020; Issa et al., 2021; Mutungi et al., 2023; Kamugisha, 2023; Izdori et al., 2025), thus overlooking the critical role of chain governance in influencing food loss and waste.

Moreover, a few existing pineapple research works have examined issues such as opportunities and challenges of smallholder pineapple farmers in improving rural livelihoods (Haji and Babune, 2023), pineapple diversity and generic identity (Abdalah et al., 2018), the impact of savings and credit cooperative societies services on pineapple growers income (Pesha and Mbawala, 2018), and the factors influencing sustainability of improved pineapple production technologies (Mauya, 2016). These studies lack detailed information on the existing governance structures, coordination of the pineapple value chain, and their connection with FLW. This study seeks to bridge this gap by exploring how governance structures influence FLW in the Tanzanian pineapple value chain. Specifically, the study has two objectives: (i) to map actors and identify governance structure in the Tanzania pineapple value

chain and (ii) to explore the role of governance structures, coordination, and power dynamics in influencing food loss and waste across the

## LITERATURE REVIEW

This study assimilates elements of resource dependence theory and institutional theory to assess the actor relationships, coordination, and power asymmetry and their influence on FLW. Factors like governance structure, power dynamics, coordination, and compliance were assumed to influence FLW in the pineapple Value chain. Resource Dependence Theory (RDT) examines the relationship between organizations and their external environment (Viscardi et al., 2024). It highlights how organizations depend on external resources such as finance, inputs, technology, information, and market access (Wry et al., 2013), which lead to interdependencies within a network. For instance, small-scale farmers lack the financial resources to invest in modern storage facilities or processing technologies, resulting in higher levels of food loss. According to Pfeffer (1978), firms develop dependencies on the provider of resources due to external constraints, and these dependencies can vary in strength and may be reciprocal. In this study, the main concepts from the resource dependence theory include power imbalances (differences in bargaining power) and interdependencies among value chain actors. In the context of FLW, RDT suggests that food loss and waste can occur when organizations lack access to essential resources that could improve efficiency and reduce food loss and waste.

Institutional Theory (IT) focuses on how rules, norms, and beliefs influence organizational behavior and decision-making. Food loss and waste can be regarded as a result of informal and formal institutions governing relations in the value chain (Cromwell et al., 2025). Social organizations, service companies, and regulatory authorities can impact the value chain (Alam, 2022), and high reliance on external entities and limited information exchange among actors have been identified as crucial challenges for reducing food waste in supply chains (Ramanathan et al., 2024). Institutional theory can be used to explain the barriers to FLW reduction in the value chain.

## MATERIALS AND METHODS

### Data collection

This study was conducted between February and August 2024 in the Dar es Salaam, Geita, Morogoro, and Pwani regions of Tanzania. The regions accounts for the major pineapple-producing areas and potential markets (URT, 2021). A qualitative research approach was adopted. Key informant interviews and focus group discussions (FGDs) were employed in gathering data. Pineapple farmers were recruited for the study through agricultural officers in the areas, and only farmers with at least 2 years of pineapple farming experience were considered for this study. Seven (7) focus group discussions with 5-11 participants were formed. Furthermore, twenty-five (25) semi-structured interviews were conducted with traders, processors, agricultural officers, and stakeholders from

NGOs and the government. Agricultural officers in the study areas were contacted to identify pineapple farmers and solicit their willingness to participate in the group discussions. Key informants were recruited using purposive and snowballing techniques. Participant characteristics are presented in table 1.

Before commencing with data collection, the researchers prepared, pre-tested, and revised the interview and FGDs guide, where it was necessary. The interview guide (Appendix 1) included 13 open-ended questions covering actors, market linkages, pricing, pineapple quality standards, handling practices, and the causes of losses in the pineapple value chain. The interviews and FGDs were conducted in Kiswahili since it is the common means of communication in Tanzania. Dur-

ing data collection, the participants were asked permission to record the discussions and the interviews. All interviews were face-to-face except for two that were conducted by telephone. FGDs lasted between 55 and 97 minutes, whereas interviews were between 30 and 45 minutes. To ensure validity and reliability, researchers asked similar questions to participants unless a follow-up question was needed for more understanding, and all FGDs were well-moderated and recorded. Sampling and data collection were concluded, adhering to the principle of theoretical saturation. That is when no new information or theme emerged from additional responses (Hennink & Kaiser, 2022).

**Table 1. Participants in the FGDs and KII**

<b>Focus Group Discussions</b>			<b>No. of participants</b>	
<b>Type of participants</b>	<b>Region</b>	<b>No. of FGDs</b>	<b>Male</b>	<b>Female</b>
Farmers, traders, and processors	Geita	3	15	10
Farmers and traders	Morogoro	1	5	3
Farmers and traders	Pwani	3	14	4
		<b>7</b>	<b>34</b>	<b>17</b>
<b>Key Informants Interviews</b>			<b>No. of participants</b>	
<b>Type of participants</b>	<b>Region</b>	<b>No. of KIIs</b>	<b>Male</b>	<b>Female</b>
Traders, and processor	Geita	5	2	3
Farmers, processor	Pwani	7	5	2
Wholesalers, processor	Morogoro	7	5	2
Traders, and Exporter-(Zawadi	Dar es Salaam	6	5	1
Agrifoods)		<b>25</b>	<b>17</b>	<b>8</b>

Source: Authors' field survey data

**Data analysis**

Value chain mapping and thematic analysis were employed in analyzing data. Mapping the value chain is a necessary first step for the value chain analysis (Hellin & Meijer, 2006; Stein & Barron, 2017). Thematic analysis is useful in exploring experiences, views, and opinions (Chen et al., 2019). The recorded discussions and interviews were transcribed verbatim in Kiswahili and translated into English for further analysis. For accuracy, the transcripts were cross-checked against the original recordings, and notes were taken. Further, using qualitative data analysis software (NVivo 10), codes and categories were generated regarding the predetermined themes as shown in Table 2, Table 3, Table 4, and Table 5. Direct quotes from participants have also been presented to amplify participants' views.

**RESULTS AND DISCUSSION**

**Pineapple value chain mapping**

The pineapple value chain was structured based on the information collected from value chain actors. Identified actors in the pineapple value chain include farmers, brokers/local traders, wholesalers, processors, and retailers. Consumers have been depicted as the end-users. Both the domestic and export value chain were identified. The significant roles of

actors include input supply, production, collection, trading, processing, and consumption. Figure 1 depicts the value chain map showing the stage/functions, key actors, and supporting actors. Pineapple farmers in the study areas mentioned that they acquire inputs such as fertilizer from local traders and some from government-subsidized fertilizer through their local government leaders. An informal supply of inputs, such as pineapple seeds and fertilizer, exists through farmer-to-farmer exchanges. The labor employed in land preparations and harvest is mainly hired. Usually, farmers pay for land preparations and weeding costs, whereas the buyer incurs harvesting costs (labor). Farmers incur harvesting and collecting costs when they take pineapples to the market directly.

Smallholder farmers are the dominant pineapple producers and are the primary and most significant actors in the value chain in the study areas. Most farmers own less than one hectare, and their main roles in the value chain include land preparation, planting, farm management, harvesting and marketing. Most farmers sell pineapples to the local traders/middlemen at the farm level. However, they also sell to retailers and consumers at local markets. Grading and sorting are done mostly by local traders (also referred to as brokers) in agreement with farmers. Farmers have limited access to markets and resources. Local traders and brokers collect and resell pineapples to wholesalers and processors. They serve as a link between farmers and

buyers. Their role included buying, assembling, and reselling. The mode of transportation to collection centers or local markets is largely by motorcycle, bicycle, or mini truck. The major buyers are wholesalers, retailers, and processors responsible for procuring, aggregation and distributing pineapples to other parts of the country. Wholesalers and processors use local traders (brokers) to collect pineapples from the farmers. However, they can also purchase pineapples directly from the farmers. Wholesalers own trucks or hire from private transporters, and transportation costs depend on the distance and capacity of the truck. They transport and sell to the large markets in big cities and others export to nearby countries like Kenya. Payments from wholesalers to farmers are mostly made through local traders. Retailers in the pineapple value chain typically perform the last marketing role. Retailers sell small amounts of pineapples, around forty to fifty pineapples a day. They sell at their stands alongside the roads or market centers, and some sell as street sellers. The results revealed limited procurement and pineapple handling capacity because of a lack of finance, transportation, and storage facilities.

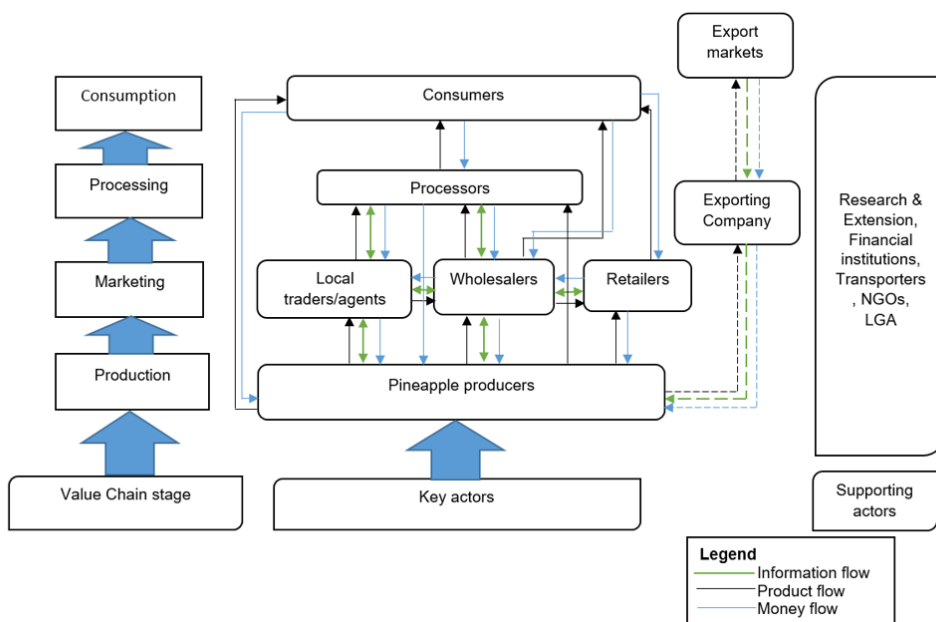
The results also revealed that fresh pineapple processing is not well established as there are few processors, mainly small-scale processors, identified in some areas. Processed products include fresh juice, pineapple wine, dried and fresh pineapple slices for direct consumption. Two large processors (Sayona and Bakhresa) were identified and interviewed. However, they produce fresh pineapple juice among other products. Large processors primarily procure pineapples through purchase orders issued to middlemen or agents, while small-scale processors typically source directly from farmers or local traders. Big pineapples are directed to the fresh produce market, whereas smaller, lower-priced pineapples are often used in processing. It should be noted that processors use a small portion of the pineapples. Likewise, van der Maden et al. (2021) found that most horticultural produce in Tanzania is consumed locally as

fresh produce, with only a small portion being processed. This leaves unexploited potential for reducing food loss and waste and increasing economic value.

Payments by large processors are generally made based on the weight of the pineapples, calculated per kilogram. Pineapple processing in Tanzania remains limited and faces numerous challenges. The export filament of the pineapple value chain was found to be at an infant stage. One of the fresh pineapple exporters was interviewed and revealed that the export chain is still struggling and faces many challenges, including meeting the requirements to preserve pineapples from the farm to the final customers. Supporting actors found in the study areas were agricultural extension officers, private transporters, researchers, the Small Industry Development Organization (SIDO), the Tanzania Horticultural Association (TAHA), and the local government authorities. The current assistance from the supporting actors is insufficient in terms of extension services, research, and financing, highlighting the need for collaboration between the government and the private sector to achieve the desired outcomes.

Access to formal financial institutions, including bank accounts, is similarly gendered. A large proportion of fisherfolk lack bank accounts (91.44), significantly higher than Liberia’s national unbanked rate (71.40%) (the Global Economy. com,2025) . However, men (71.43%) are far more likely to have bank accounts than females (25%) as shown in Table 4. Development finance theory suggests that female’s exclusion from formal finance is often rooted in limited human capital—such as literacy and numeracy skills—and restricted access to social and economic resources. The findings reflect this, with female having far lower education levels, making it difficult for them to meet documentation requirements for bank accounts or loans. This aligns with Pomeroy et al. (2020) and Letouze et al. (2021), who both emphasize education as a central barrier to financial inclusion.

**Figure 1. Value chain map of Tanzanian pineapple**



Source: Researcher conceptualization from the field data (2024)

**Local governance structure of the pineapple value chain**

The governance structure refers to the organization of the value chain and coordination among the actors that facilitate the product flow from production to the end user (Tadesse & Bekele, 2022). It is influenced by actors' interdependence in the supply chain and by differences in market power (Trienekens, 2011). The results revealed that three governance structures exist in the Tanzanian pineapple value chain. The most prevailing structure is market governance, although captive and relational governance can be observed. The market governance is based on the spot market relationship, where the prevailing market price guides the interactions. The transactions among pineapple farmers and buyers are simple. The price is typically determined based on the quality and size of the pineapples. Similar results have been observed by Cromwell et al. (2025), that fruits of a large size fetch better prices than medium or small ones. On average, farmers sell pineapple for 760 Tanzanian shillings, equivalent to €0.26 per pineapple.

In the captive governance, wholesalers assisted by the local traders/agents were observed to be the key value chain drivers. Likewise, through the agents, processors were observed to have control over the pineapples supplied and the price. Focus group discussions with farmers revealed their position in the price setting and negotiations as very weak, reflecting captive relationship they operated in. The upfront financial assistance advanced by traders assures local traders and brokers exclusive rights to buy pineapples at harvest. This creates a lock-in relationship between farmers and prospective buyers, cementing the captive governance structure. A farmer (F3SV) from Sungusila village responded:

**F3SV:** *“Once the farmer takes some amounts from the middlemen, that farm is no longer under his authority. He can't even sell because he'll be held responsible”.*

*Likewise, substantial dependence on brokers' financing results in losses if there is any delay on the brokers' agreed harvesting date, and also limits farmers' ability to search for alternative buyers and competitive prices. When buyers fail*

*to fulfill their commitments, farmers are unable to sell their pineapples to other buyers due to these exclusive agreements, which further intensify their financial vulnerability, as one of the key informant farmers (KIF1) highlighted: “For example, a buyer might promise to come on a certain date, but they don't show up. You're not allowed to sell to another buyer during that time. When they finally come, you find some pineapples have spoiled on the farm, and out of 1,000, you might lose 150 to 200 fruits.”*

The relational governance structure is observed when coordination and transactions between farmers and local traders or local traders and wholesalers are based on trust, mutual dependence, and long-term relationships rather than formal contracts or standardized rules. Similar results were obtained by van der Maden et al. (2021). In the Tanzania pineapple value chain, local traders and middlemen usually maintain relationships with farmers by providing financial assistance when needed. For example, local traders or middlemen offer credit or upfront payments to farmers, which assist in meeting their different needs. Although such assistance may not guarantee a good market, it can also lead to loss if pineapples are ready to be harvested and the trader has not shown up. It also limits the farmer from searching for other buyers who could offer better prices during harvest.

**F3SV:** *“I think maybe another reason causing pineapple spoilage is these middlemen, because, when middlemen provide pre-finance credit to the farmer; they tell you not to sell the produce to another buyer. As a result, the middlemen leave those pineapples to ripen excessively before they show up for harvesting, causing losses on the farm.”*

Generally, the governance structure in the study areas favors the wholesalers and the local traders/brokers. The source of their power and dominance arises from two areas, i) possession of information about pineapple supply and demand, and ii) resource endowment, as traders have larger capital, enabling them to advance credit to farmers, thereby effectively creating the lock-in captive relationship that assures them of supply and low prices, hence dominating the channel.

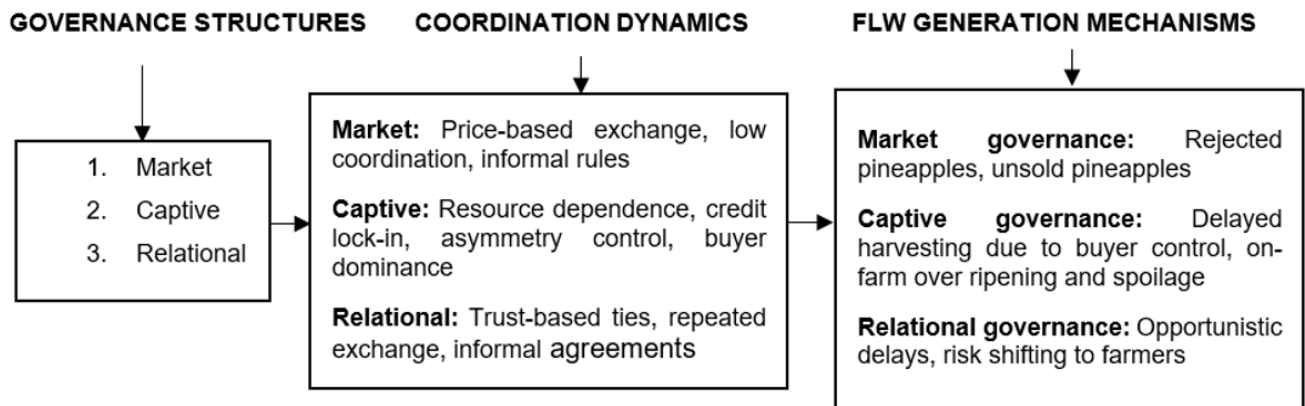
**Table 2. Existing governance structures (Theme #1)**

Codes	Categories	Theme
-They won't sell to just anyone; they have to look for you -Dependency on the broker for market access -I will give you a little money so that when the fruits are ready, you can sell them to me -Farmers find themselves without the power to sell elsewhere -Once the farmer takes some amount of money, that farmer is no longer independent -Farmers bear a loss for not being able to sell to any buyer	Captive governance and farmer dependence	
-I sell to buyers at the market -The relationship with traders starts when I have a product they want to buy -My interaction with brokers ends after selling -Once we purchase from the farmer, the transaction is complete	Market governance	Existing governance structures
-Small traders are from here; we know them -Brokers and local traders assist farmers when in need -Most relationships result from financial assistance -Middlemen can give farmers money, even if the produce has not ripened	Relational governance	

Source: Authors' own editing

The summary of governance structures and FLW mechanisms in the Tanzanian pineapple value chain is presented in Figure 2 below.

Figure 2. Governance structures and FLW mechanisms in the Tanzanian pineapple value chain



Source: Authors' own editing

### Coordination and collaboration

Weak coordination and lack of formal institutional support appeared as a recurring theme across the discussions and heightened the challenges in the pineapple value chain. The results revealed weak horizontal and vertical coordination in the study areas. Farmers reported limited involvement by institutions, including financial support and organized farmer groups. A farmer (F2KV) from Kakubilo village explained:

**F2KV:** "For example, here in Kakubilo, we don't have other stakeholders because we don't even have institutions dealing with pineapples. Because when you mention institutions or stakeholders, it means maybe there are loans that we get from institutions, we don't have loans, as pineapple farmers".

The collaboration among actors is often limited and transactional. While pineapple farmers, brokers, and traders depend on each other for financial and logistical support, their relationships seldom extends to mutual problem-solving and strategic partnerships. Inadequate information flow among actors hinders coordination and decision-making. Similarly, a lack of farmers' associations, such as producers' cooperatives, leads to weak bargaining power. Studies support that collaborative strategies have the potential to reduce FLW by directly link farmers with buyers, processors, and supporting actors (Petrescu-mag et al., 2024; Voge et al., 2023; Izdori et al., 2025). When asked about farmer groups or associations, another farmer (F4KV) from Kakubilo village responded:

**F4KV:** "We don't have that; everyone farms individually and sells individually, so there's no farmers' group that buys collectively like they do with cashews; everyone sells individually."

Unlike farmers, incidences of collaboration have been observed among traders as they share transportation and other resources. Traders were observed to have their associations, as it was observed during the visit at the Buguruni market in Dar es Salaam. This reveals potential opportunities for cost reduction and improving efficiency in the value chain. Similarly, the

government's role in providing subsidized fertilizer, however limited, signifies progress in enhancing coordination.

Furthermore, farmers stated that there was no equal access to information across chain actors and that information asymmetry affects their decision to sell, particularly to the large processors. The large processors usually use agents to collect pineapples from the farmers through purchase orders. The order specifies the amount required and the price offered per kilo of pineapples. When collecting pineapples from the farmers, the agents offer a price below what is stated in the purchase order. Petrescu-mag et al. (2024) also pointed out that limited market access and low prices can result in unsold and wasted products.

The results reveals that weak regulatory frameworks and limited enforcement mechanisms contribute to significant FLW. Local traders and wholesalers share information on pineapple prices and supply conditions in the study areas. Hence, the wholesalers and the agents take advantage of the profit over the farmers. Apart from individual networks and business relationships, formal contracts are lacking during transactions. Vidanapathiarana et al. (2020) reported the similar results, that the agents supplying processors have informal (verbal) agreements with farmers. This indicates that the actors in the value chain rely highly on informal agreements and mutual trust. From an institutional theory perspective, the lack of regulatory enforcement and formal contracting mechanisms to protect actors from breaking the agreements introduces dependency risks that may result in losses. Moreover, limited coordination among stakeholders like government agencies, business associations, and researchers is a substantial barrier to improving the value chain and reducing food loss and waste. One of the small processors (KISP2) expressed a lack of commitment from supporting actors:

**KISP2:** "They said we would sign contracts later. They told us to build the facility, and once the business picked up, they'd find us a market. Then, we'd sign contracts to start repaying. That's where we're at now. If we could find an individual to advance our business, we'd repay them and grow our capital."

**Table 3. Coordination among actors in the value chain (Theme #2)**

Codes	Categories	Theme
<ul style="list-style-type: none"> <li>-Relationship is when I am in tight condition</li> <li>-The relationship is mainly commercial</li> <li>-Majority have relationships with local traders/brokers</li> <li>-Farmers have no relationship with end user</li> <li>-Brokers are the link between farmers and buyers</li> <li>-Some collaboration among farmers</li> <li>-Information flows from wholesalers to brokers to farmers of fellow broker</li> <li>-Farmers share pineapple information with brokers</li> <li>-The government is involved in bringing us subsidized fertilizer</li> </ul>	Actor relationship and collaboration	
<ul style="list-style-type: none"> <li>-I tell him to trust me</li> <li>-They said we would sign contracts later</li> <li>-The one who provides money will then come and deduct it during harvest</li> <li>-I don't have any contracts with anyone</li> <li>-In fact, no contract, but we use the purchase order</li> </ul>	Informal agreements	Weak institutional support and coordination
<ul style="list-style-type: none"> <li>-Farmers lack market information</li> <li>-Lack of institutions that lend to farmers</li> <li>-We don't have other stakeholders because we don't have institutions dealing with pineapples</li> <li>-Farmers don't receive any kind of empowerment</li> <li>-Lack of feedback from researchers</li> </ul>	Limited institutional support and research involvement	
<ul style="list-style-type: none"> <li>-As farmers, we have nowhere to go for loans</li> <li>-Everyone farms individually and sells individually</li> <li>-No farmer group that buys collectively like they do with cashew</li> </ul>	Financial and organizational challenge, Lack of farmer organization	

Source: Authors' own editing

**Power dynamics**

Power asymmetry between farmers and other actors was frequently presented. The study indicates the existing inequalities in bargaining power between pineapple producers and brokers, who often set the prices and control access to buyers. The lack of access to direct markets and dependence on brokers weakens farmers' bargaining power. Hence, farmers are forced to sell pineapples at lower prices than expected. With limited options and information asymmetry, farmers fail to negotiate better prices, underpinning dependence on brokers who take advantage during selling to end buyers. To explain more, a farmer (F21MV) from Msinune village said:

**F21MV:** *"When the broker comes and tells you he will buy your pineapples for five hundred shillings, you agree to take your five hundred shillings. If there is seven hundred or a thousand shillings, only the broker knows, because it is the one who brought the buyer"*.

With this power imbalance, farmers do not benefit from potential prices that could have maximized their gains. Long-

term purchase commitments among local traders and farmers have created trust among them. Farmers may access loans from local traders/middlemen, and the agreement is always to sell pineapples to them during harvest. That means, during harvest, the local trader will take pineapples worth an amount equivalent to that provided to the farmers in return.

Local traders and wholesalers often exploit farmers by offering unfair prices, exacerbating power imbalances. During focus group discussions, farmers revealed that, during peak season, wholesalers or local traders/brokers determine pineapple prices. However, when pineapples are out of season, prices are set by negotiation. Generally, farmers have limited bargaining power due to their dependence on middlemen and limited markets. This power imbalance among actors within the pineapple value chain leads to weak coordination (Assefa et al., 2022), which is evident in its potential for food loss (Herzberg et al., 2022; Ramanathan et al., 2024). From a resource dependence perspective, FLW results from unequal power and constrained decision-making within governance structures.

**Table 4. Power dynamics (Theme #3)**

Codes	Categories	Theme
<ul style="list-style-type: none"> <li>-Without brokers, you might sell at different prices</li> <li>-Lack of market information</li> <li>-The middlemen will come and lower the price</li> <li>-The farmer doesn't have direct contact with the buyer</li> <li>-Honestly, it is mostly the buyers who set the price</li> </ul>	Lack of bargaining power	Power dynamics
<ul style="list-style-type: none"> <li>-Buyer availability determines the decision to harvest</li> <li>-Once the farmer receives financial assistance, he loses authority over his farm</li> <li>-Farmers are glued to the financial assistance received</li> <li>-Pineapples ripen excessively in the field when buyer delay</li> <li>-Unfulfilled promises by buyers cause the pineapple to spoil</li> </ul>	Decision-making constraints	

Source: Authors' own editing

### Quality and standards compliance

Buyers and processors set quality standards for pineapples with different levels of specificity. Some buyers require specific sizes, ripeness levels, and physical attributes, which when farmers fail to meet, result in the rejection of the already harvested pineapples. This is supported by FAO (2019), that quality and grading standards are critical in determining product acceptance. Herzberg et al. (2022), pointed out that private quality standards contribute to food loss at the upstream stage of value chains. Such standards result in the exclusion of suitable produce for consumption that does not meet specific market criteria. Moreover, the compulsory quality standards by buyers in the export market aggravates pineapples' loss and waste. Farmers struggle not only to meet the requirements but also endure losses if the pineapples fail to meet the specified quality standards, as explained by one of the exporters (key informant interview 10):

KII10... "we may request ripe, undamaged pineapples of a particular size, but not all harvested fruits meet these criteria. If we purchase, say, 20 tons, we often find that 1-2% do not meet the standards..."

This is challenging for pineapple farmers who may not have the required knowledge, calling for training on quality

standards and the formation of uniform grading systems. The lack of formalized grading systems is evident in the pineapple value chain as different requirements for size and quality exist. While some mentioned three categorized sizes (large, medium, and small), in some areas, pineapples are categorized as large, medium, small, and "rejects."

KIF1: "There are large ones, medium ones, small ones, and others they call "rejects," which are very small. When they come to harvest, they take everything. But when it's time to count, you'll find that three of the smallest ones are counted as one pineapple. They say these are like waste, and that's why we complain about market issues"

However, while this informal categorization is a common practice, it lacks a standardized grading system that could improve market efficiency and reduce pineapple losses. Cromwell et al. (2025) in their studies also found that, informal standards applied were based on size, fruit maturity and appearance. With standardized grades, farmers and traders would ensure quality requirements by the markets and reduce chances of rejection while improving market access to high-quality pineapples. Codes generated in Table 5, indicates that not all harvested pineapples meet standard requirements and hence they get rejected.

**Table 5. Compliance to quality and standards (Theme #4)**

Codes	Categories	Theme
-Not all harvested fruits meet those criteria -We take only pineapples that are semi-ripen, not fully ripen and not green ones	Inability to meet quality requirements	Compliance with quality and standards

Source: Authors' own editing

### Implications of the study

This study contributes to governance and food loss literature by showing how institutional voids reinforce asymmetric resource control structures, generating governance mechanisms that increase FLW in agricultural value chains in developing countries. In particular the results show that the captive governance structure reinforced by informal credit dependencies and weak regulatory enforcement limit farmers' strategic autonomy and decision making, raising on-farm and postharvest losses. By linking governance typologies to loss generation mechanisms the study posits that improving coordination alone in agricultural value chains is insufficient without addressing power and institutional weaknesses. Addressing food loss and waste challenges rooted in governance, the findings emphasize the need for a comprehensive approach that combines empowering farmers, infrastructure development, and policy interventions to create a more inclusive and sustainable value chain. Collective actions could help farmers link with buyers, strengthen their bargaining power, negotiate better prices, access the market directly, and reduce FLW.

### CONCLUSION

The study findings indicate that governance structures, power dynamics, and coordination within the pineapple value

chain in Tanzania play a vital role in influencing the efficiency of resource allocation and the management of pineapple losses and wastes. The chain is characterized by poor governance structures, weak multi-sector collaboration, and limited infrastructure, exacerbating FLW. Power imbalances among value chain actors, particularly between farmers and middlemen, create inefficiencies, contributing to FLW. Lack of formal structures and existence of power dynamics where brokers and buyers influence the prices and market significantly, position actors, especially farmers at risk of incurring losses or price disputes.

In addressing food loss and waste in the pineapple value chain, the findings of this study highlight the need for a more coordinated approach among stakeholders to promote a more resilient and sustainable value chain that benefits all involved actors. Existing power imbalances can be addressed through strengthening institutional support and enhancing coordination mechanisms. Farmers' empowerment through associations and training programs can enhance their bargaining power, increase fairness, and reduce pineapple loss and waste along the value chain. Further research could explore different agricultural value chains in Tanzania to assess whether comparable challenges and power disparities occur across sectors.

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# DISTRESS SALES AS LIVELIHOOD STRATEGY: COMMERCIALIZATION AND THE PERSISTENCE OF POVERTY AMONG WIDOWED FARMERS IN CONFLICT-AFFECTED NIGERIA

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**Abstract:** *Widowhood is a catastrophic event for women farmers at any stage of their lives, with serious implications for their well-being. We examined the effect of household commercialization on poverty of the widowed cowpea farmers in North-east Nigeria. Multistage sampling procedure was employed which arrived at 525 respondents. The data were collected using schedule interview and analysed using both descriptive and inferential statistics (multiple regression). The result revealed that Household commercialization index (HCI) was 55.44% and 54.19% for the IDPs and host communities respectively. The average progress out of poverty index (PPI) score was lower for IDP farmers (33.55) compared to host community farmers (42.96) with homogeneity in both. Explanatory variables influencing PPI explained 35.30% of its variation, Legume farming experience and value harvest were found to improve PPI, Household size and IDP status reduce the PPI. The HCI explained 4.7% of Poverty of widowed cowpea farmers, and the HCI had an inverse relationship with poverty. All in all, widowed cowpea farmers' household commercialization increases poverty by 0.126, with heterogeneity among households with higher legume farming experience, lower household sizes, IDPs host communities and higher value of cowpea which experienced less poverty in the study area. Strengthening cooperative development, promoting value addition of cowpea products, expanding access to financial services and targeted support for widowed farmers is hence recommended.*

**Keywords:** *Boko Haram, Market participation, Female headed household, Vulnerability, IDPs, Borno*  
(JEL code: Q12, I32, Q13, J16)

## INTRODUCTION

Cowpea (*Vigna unguiculata*) is a hardy and nutritious legume, highly adaptable to diverse soils and cropping systems, and holds considerable economic and nutritional importance in Nigeria, the world's largest producer and consumer. This is especially true in the arid and semi-arid North-East region, where it serves as a staple food, a critical source of income, and a component of soil fertility management (IITA, 2024;

Bolarinwa et al., 2022). Historically, cowpea production has been a cornerstone of rural livelihoods in this region (Nwagboso et al., 2024).

However, the North-East has been subjected to profound socio-economic disruption due to the Boko Haram insurgency, recurrent flooding, climate change vulnerability, and farmer-herder conflicts, resulting in over two million internally displaced persons (IDPs) (IOM, 2023; FAO, 2017). These crises disproportionately affect women, leaving many widowed and

severed from their traditional agrarian livelihoods (UNHCR, 2017). The resultant loss of spousal support, land access, and social networks has exacerbated poverty and vulnerability among these women, compelling a re-evaluation of their livelihood strategies (Barbelet et al., 2021).

Agricultural commercialization, the shift from subsistence to market-oriented production is widely posited as a viable pathway out of poverty for smallholder farmers. Empirical studies, such as those by Ogutu, Gödecke, and Qaim (2019) in Kenya and Simtowe et al. (2017) in the Democratic Republic of Congo, demonstrate that commercialization can increase household incomes, improve livelihoods, and build resilience to shocks. This perspective is reinforced by Cazzuffi, McKay, and Perge (2020), who found a positive linkage between commercialization and household welfare in rural Vietnam, and by De Janvry and Sadoulet (2009), who argue for its primacy due to farmer heterogeneity.

The gender dimension of this pathway, however, revealed significant constraints. Women, particularly in sub-Saharan Africa, consistently face gender-based barriers in accessing land, credit, and extension services, limiting their full participation in commercial agriculture (Horn et al., 2022; Mukaila, 2024; Shehu et al., 2025). Recent research by Shehu et al. (2024a) on smallholder cowpea farmers in Nigeria explicitly highlights these gendered paths to market participation, the finding showed that female farmers face distinct socio-structural obstacles compared to their male counterparts. This suggests that the poverty-reduction potential of commercialization cannot be assumed to be gender-neutral.

Furthermore, the relationship between commercialization and poverty is nuanced and may be mediated by the type of crop and household vulnerability. Studies focusing on staple food crops present a more complex picture. Birhanu, Tsehay, and Bimerew (2021), in their study on cereal commercialization in Ethiopia, hypothesize that commercializing staple foods could increase multidimensional poverty if it occurs at the expense of household food consumption, a scenario of "distress sales." This contrasts with findings from Chinese contexts, where Wang et al. (2024) found agricultural commercialization significantly reduced multidimensional poverty, and from a multi-country study in Africa where Mgonezulu et al. (2024) concluded poverty was higher among subsistence farmers than commercial ones in Malawi, Tanzania, and Nigeria. This divergence underscores that commercialization's impact is context-dependent, influenced by initial resource endowments, market structures, and household vulnerability profiles.

Despite this growing body of literature, a critical gap remains. There is a paucity of research that specifically examines the commercialization experiences of widowed women farmers in conflict-affected areas. This group represents a unique intersection of gender and vulnerability, often managing households alone under the compounded stresses of displacement, asset loss, and psychological trauma. As noted by Vasilyeva et al. (2023), institutional factors such as conflict and displacement profoundly shape economic mobility. The specific mechanisms through which widows in settings like North-East Nigeria engage with markets, and whether such

engagement alleviates or exacerbates their poverty, are poorly understood.

Existing humanitarian analyses, such as those by Barbelet and Wake (2020), report a high rate of exclusion of women, particularly widows, from formal support systems, pushing them towards independent but precarious livelihood strategies like small-scale farming. This makes the study of their agricultural decisions, especially regarding a key crop like cowpea, not only an academic exercise but a pressing policy concern.

This study, therefore, aims to fill this gap by investigating the effect of household cowpea commercialization on poverty among widowed farmers in North-East Nigeria, with explicit attention to differences between those in IDP settings and host communities. The study is grounded in an income-based concept of poverty, operationalized through the Progress out of Poverty Index (PPI), which assesses the likelihood of a household living below a given poverty line based on proxy indicators of wealth and capacity.

The research seeks to answer the central question: Does household commercialization of cowpea contribute to progress out of poverty for widowed farmers in this conflict-affected context, or does it represent a distress strategy that undermines food security and well-being?

In doing so, this paper contributes to the literature in three key ways: It provides empirical evidence on the livelihood strategies of a critically vulnerable yet understudied group (widowed women) in a protracted crisis zone; It interrogates the universal poverty-reduction narrative of agricultural commercialization by testing it in a context of acute gender and displacement-induced vulnerability; It offers evidence-based insights for policymakers and humanitarian actors aiming to design targeted interventions that support sustainable livelihoods for widowed farmers, aligning with the Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty), SDG 5 (Gender Equality), and SDG 10 (Reduced Inequalities).

## LITERATURE REVIEW

The relationship between agricultural commercialization and poverty is a central theme in development economics, drawing from theories of market integration, household economics, and livelihood resilience. The prevailing orthodoxy, rooted in the market integration model (Timmer, 1997; Pingali & Rosegrant, 1995), the model posits that increased market participation allows smallholder farmers to specialize according to comparative advantage, achieve economies of scale, and realize higher incomes from cash sales. This enhanced income is theorized to catalyse a virtuous cycle of investment in productivity-enhancing inputs, improved household consumption, and ultimately, a sustained exit from poverty (De Janvry & Sadoulet, 2009; Cazzuffi et al., 2020). This framework underpins numerous policy prescriptions advocating for the commercialization of smallholder agriculture as a primary engine for rural poverty reduction.

However, this linear, optimistic model is increasingly challenged by empirical evidence highlighting the contingent and

often heterogeneous outcomes of commercialization, particularly for vulnerable groups. The New Economics of Labour Migration (NELM) perspective (Stark & Bloom, 1985) and Livelihoods Approaches (Scoones, 1998; Ellis, 2000) provide more nuanced frameworks. They conceptualize households not as profit-maximizing firms but as complex units managing a portfolio of assets (natural, human, financial, social, physical) to navigate risks and secure well-being. From this viewpoint, market participation is one strategy among many, and its adoption and impact depend critically on a household's initial asset endowment, its vulnerability context, and intra-household dynamics.

When farmers sell surplus produce beyond subsistence needs, commercialization directly increases disposable income (Ogutu et al., 2019). This income can be used to purchase a more diverse basket of goods and services, invest in children's education or health, and acquire productive assets, thereby reducing multidimensional poverty as measured by indices like the PPI (Wang et al., 2024). This pathway aligns with the classical market integration theory.

Conversely, commercialization can be a symptom of vulnerability rather than an opportunity. Faced with liquidity constraints, debt, or immediate shocks (e.g., illness, school fees), households may engage in distress sales of food staples, selling a portion of their harvest needed for home consumption (Birhanu et al., 2021). This reduces the quantity and quality of food available for the household, potentially leading to seasonal hunger, poor nutrition, and increased reliance on purchased food, which may be more expensive or less nutritious. In this scenario, while cash income may see a short-term rise, the household's food security and overall well-being deteriorate, creating a perverse outcome where commercialization exacerbates a core dimension of poverty.

This dual-pathway model is supported by contrasting findings in the literature. Mgomezulu et al. (2024) found poverty lower among commercial farmers in three African countries, suggesting the dominance of former pathway. In contrast, studies in highly vulnerable contexts, such as those on female-headed households in Ethiopia, warn of the risks of later pathway, where market participation does not translate into improved food security or resilience (Kuma et al., 2019).

In addition, gender is a fundamental axis structuring access to and control over the assets necessary for successful commercialization. Feminist political economy critiques highlight how patriarchal norms restrict women's land ownership, limit their access to credit and extension services, and assign them the bulk of reproductive labour (Agarwal, 1994; Doss, 2018). For widows, these constraints are often intensified. The death of a spouse can trigger asset-stripping by relatives, loss of customary land rights, and a collapse of social networks that previously facilitated market access (Peterman, 2012; FAO, 2020). Their commercialization decisions are therefore made from a position of significantly diminished "asset pentagon" (Scoones, 1998), particularly in terms of financial, social, and natural capital.

Furthermore, widows in conflict zones, such as North-East Nigeria, face a triple vulnerability: gender, displacement, and the trauma of conflict. Displacement (IDP status) represents a

severe shock to all livelihood assets, loss of land, destruction of physical capital, and disruption of social and market networks (IOM, 2023). This forces a radical reconfiguration of livelihood strategies, often under conditions of extreme uncertainty and limited state support (Barbelet et al., 2021). In this context, the decision to commercialize cowpea cannot be read simply as an entrepreneurial choice; it may be a critical survival strategy shaped by desperation and a lack of alternatives.

### Conceptual framework

Integrating these theoretical insights and empirical cautions, Figure 1 presents the conceptual framework guiding this analysis. It moves beyond a simple linear model to depict a system of relationships where the impact of cowpea commercialization on the poverty status of widowed farmers is mediated by contextual and household-level factors and can manifest in different poverty dimensions.

### Core Constructs and Relationships:

i. Contextual Vulnerability (Exogenous Shock): The conflict-induced displacement (IDP vs. Host status) acts as a primary shock, directly constraining access to key productive assets (especially land and capital) and shaping market access conditions. This sets the initial conditions for all subsequent decisions.

ii. Household Commercialization Decision (HCI): The degree to which a widow commercializes her cowpea harvest (HCI) is influenced by:

- o Asset Endowment: Farm size, farming experience, human capital (education).

- o Institutional Access: Group membership (social capital), access to market information.

- o Household Demands: Household size (consumption needs/dependents).

iii. Dual-Pathway Impact on Poverty:

- o Pathway 1 (Income Channel): Commercialization → Increased Farm Income → Increased Household Expenditure on non-food items (health, education, assets) → Reduction in Income/Multidimensional Poverty (PPI).

- o Pathway 2 (Subsistence Channel): Commercialization → Reduced Quantity of Cowpea Available for Household Food Consumption → Potential Compromise of Food Security & Nutrition. This pathway is likely dominant in cases of distress sales driven by large household needs or a lack of alternative income sources.

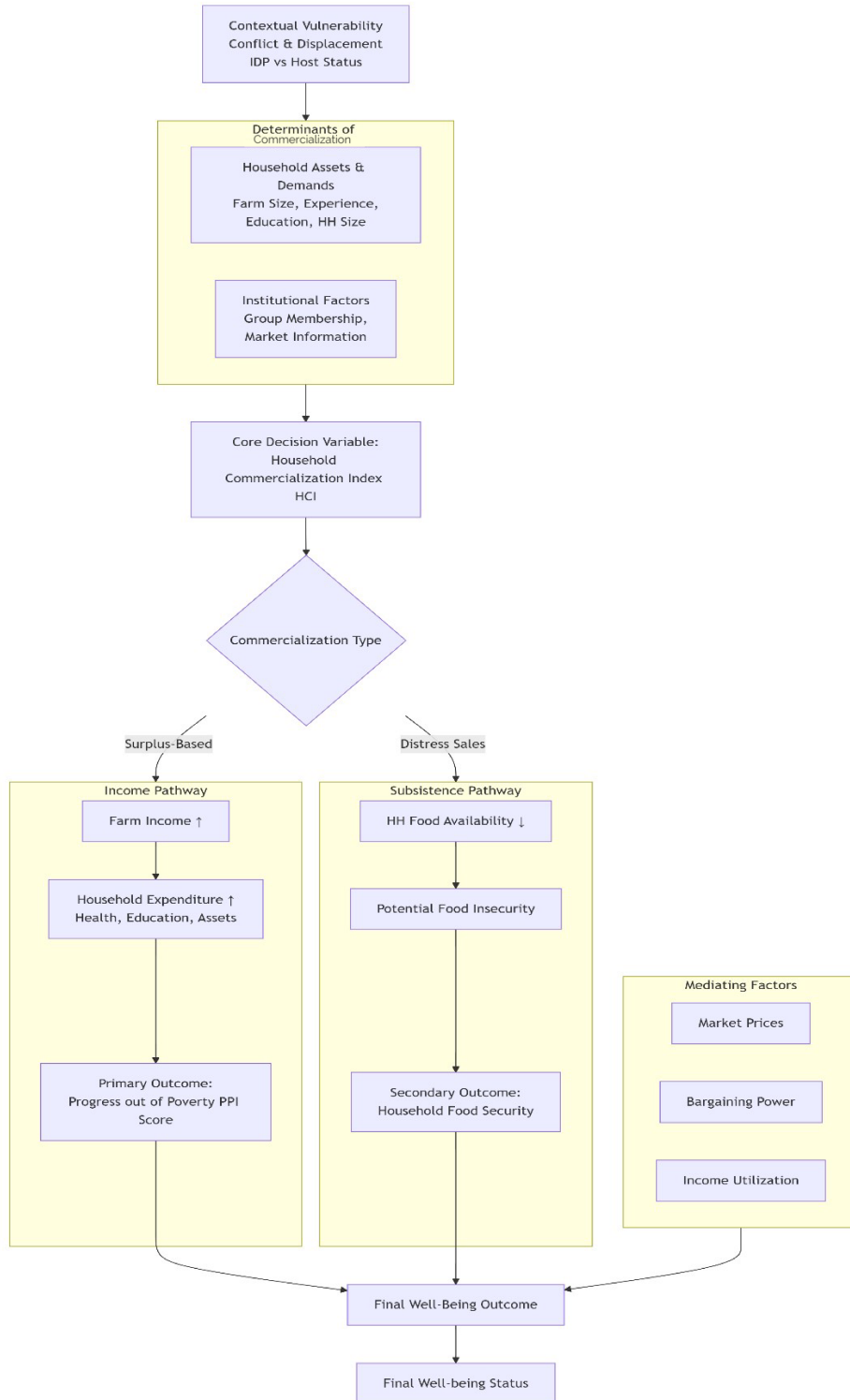
iv. The Mediating Role of Market Conditions & Agency: The ultimate effect on overall well-being (the final poverty outcome) depends on whether the income generated (Pathway 1) is sufficient to offset the food deficit (Pathway 2) by allowing the purchase of adequate and nutritious food in the market. This, in turn, is mediated by local food prices, the widow's bargaining power within the household and market, and her ability to utilize income for welfare-maximizing purposes.

v. Outcome Variable - Progress Out of Poverty Index (PPI): This study uses the PPI as its primary dependent variable. It is crucial to note that the PPI is a proxy for the likelihood of living below a national income poverty line, based on indicators of household assets and living standards. It is thus

a strong measure for Pathway 1 (income poverty) but may be less sensitive to acute, seasonal fluctuations in Pathway 2 (food security). A finding of no change or a negative relationship between HCI and PPI would strongly suggest that com-

mmercialization is failing to improve the income-based poverty status, potentially because it is of the distress-sale variety, with benefits being negated by associated costs or because income is not being converted into durable asset.

**Figure 1. Conceptual framework showing effects of widowed farmers' household commercialization on poverty**



Source: Authors' own editing

## MATERIALS AND METHODS

### Study area

This study was conducted in North-east Nigeria which consists of six states. The States are Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe. The region lies between Latitude 9° 08' to 14°N and Longitude 8° 68' to 15°E. The area occupies a land mass of 280,419 km<sup>2</sup> (National Bureau of Statistics [NBS], 2022). According to the source the region has a population of 30, 541,900.

The choice of this area is predicated on its status as Nigeria's primary cowpea production zone (IITA, 2024) and its acute vulnerability context. There is heightened poverty rate as a result of the activities of Boko Haram armed conflict in the agrarian communities which resulted into community displacements that coupled with farmer-herders conflicts, incessant floods and climate change vulnerability. These thwart so many farmers from going to their farms specifically widows (International Organization for Migration [IOM] (2023); UN-HCR, 2017). As a result, widows become vulnerable to food insecurity, harsh weather, poor sanitary materials, poor access to health services, clean water and decent living standard among others (FAO, 2018; Aderemi & Ogbeje, 2024). However, humanitarian actions are available to cushion these vulnerabilities in which the high rate of exclusion of females which the widows were the majority in the humanitarian actions was reported (Barbelet & Wake, 2020; Barbelet et al., 2021). However, legumes production such as groundnut which relatively requires less inputs that also improves the fertility of the soil through atmospheric Nitrogen fixation, the legumes in addition serve as both cash and food crop for hu-

man and animals (Witcombe & Tiemann, 2022). It further has relatively less production duration which allow quicker return on investment (Witcombe & Tiemann, 2022). It is therefore remains an alternative for vulnerable widows in north-eastern Nigeria to engage into its production and commercialisation due to their condition of poor access to resources, market value and nutrition richness it possess.

### Sampling Procedure

A multistage sampling procedure was used to select communities and respondents in the four LGAs. The technique reduces the time and cost of collecting samples from a large population to a convenient size, but goes through several stages to ensure fair representation (Rahman et al., 2022; Shehu et al., 2024a). In the first stage, four States were purposively from the six States of the North-Eastern Nigeria engulfed by the Boko Haram Insurgency, the selection was based on the intensity of the conflicts in the States, these States were Adamawa, Borno, Gombe and Yobe. In the second stage, L.G.As with a lower intensity of conflicts were proportionately randomly selected, this is to allow data collection by the enumerators, and the displaced farmers usually found IDPs in the less affected conflict area. Thirdly, list of widow farmers were collected from the extension officer of the Agricultural Development Programme (ADP) and community leaders, a listing of all active female farmers was compiled in the L.G.As selected, and 5% of the widow farmers were randomly selected from the list of the widow farmers as suggested by Krejcie & Morgan (1970) from the population of 10,500 (under 99% confidence level with 5% margin of error), which forms 525 for the study (Table 1).

**Table 1. Sampling procedure and sample size**

State	L.G.A	Sample frame	Sample size (5%)
Adamawa	Demsa	500	25
	Fufore	480	24
	Gombi	680	34
	Guyuk	540	27
	Hong	740	37
	Song	380	19
	Yola south	400	20
Borno	Bayo	640	32
	Biu	480	24
	Hawul	480	24
	Kwaya kusar	620	31
Gombe	Shani	460	23
	Akko	540	27
	Billiri	580	29
Yobe	Kaltungo	560	28
	Fika	760	38
	Nangere	820	41
	Potiskum	840	42
<b>Total</b>	<b>18</b>	<b>10500</b>	<b>525</b>

Source: Reconnaissance Survey (2022)

### Method of Data Collection

Primary data were collected through a cross-sectional survey conducted between September and December 2022. A structured questionnaire was pre-tested and refined, the pretested data was dropped during the analysis. It was administered through face-to-face interviews by a team of trained enumerators fluent in local languages (Hausa, Kanuri, and Fulfulde).

The questionnaire was digitally deployed using Open Data Kit (ODK), an open-source suite of tools for mobile data collection, on Android tablets. This ensured real-time data capture, reduced errors, and facilitated efficient data management. The instrument was designed to collect detailed information on: Socio-economic characteristics (age, education, household composition, displacement status); Farm production (cowpea farm size, farming experience, production quantity, inputs used); Commercialization (quantity and value of cowpea harvested, quantity and value sold, marketing channels used); Institutional factors (membership in farmer groups or cooperatives, access to credit, and sources of market information); and PPI indicators.

### Method of Data Analysis

The study used descriptive statistics such as frequency, percentage, mean, standard deviation to summarise the data, inferential statistics (Ordinary Least Squares (OLS) multiple linear regression) were used to determine the drivers of poverty among widowed cowpea farmers and the effect of widowed

cowpea farmers' HCI on their poverty.

The model for drivers of poverty was explicitly expressed as:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_{10} X_{10} + \varepsilon_i \quad \dots 1$$

$Y_i$  = poverty (PPI)

$\beta_0$  = intercept

$\beta$  = regression coefficients

$\varepsilon_i$  = error term

$X_1$  = Age of the farmer (years)

$X_2$  = Education (year of formal education)

$X_3$  = Farm size (ha)

$X_4$  = Legume farming experience (years)  $X_6$  =

$X_5$  = Household size (Number of persons in the household)

$X_6$  = Group membership (member=1, otherwise=0)

$X_7$  = Market information (Accessed market information=1, otherwise=0)

$X_8$  = Value of harvest (₦)

$X_9$  = Sales (₦)

While the model for the effect of HCI on poverty was explicitly expressed as:

$$Y_i = \beta_0 + \beta_1 X_1 + \varepsilon_i \quad \dots 2$$

$Y_i$  = poverty (%)

$\beta_0$  = intercept

$\beta$  = regression coefficients

$\varepsilon_i$  = error term

$X_1$  = HCI (%)

**Table 2. Description and Measurement of the Variable**

Variable	Description and Measurement	Mean	SD
<b>Dependent Variable</b>			
Progress out of Poverty (PPI)	A composite index (0-100) calculated using the official Nigeria PPI scorecard. The scorecard uses 10 simple, verifiable indicators (e.g., household size, children's school attendance, asset ownership, housing materials) to compute a likelihood score of a household living below the national poverty line. A higher score indicates a lower probability of being in poverty.	40.12	12.45
<b>Key Independent Variable</b>			
Household Commercialization Index (HCI)	The ratio of the total value of cowpea sold to the total value of cowpea production, expressed as a percentage. HCI = (Value of Sales / Value of Total Harvest) 100. It measures the degree of market orientation for cowpea.	54.56	16.12
<b>Explanatory/Control Variables</b>			
Age	Age of the respondent in years.	49.21	13.88
Education	Years of formal schooling completed by the respondent.	5.03	5.01
Farm Size	Total land area cultivated to cowpea in the last season, in hectares.	3.02	2.05
Legume Farming Experience	Number of years the respondent has been farming legumes (including cowpea).	22.98	12.45
Household Size	Total number of persons eating from the same pot and living in the same household.	7.01	2.92
Group Membership	Dummy: 1 = Respondent is a member of any farmers' group, cooperative, or association; 0 = Otherwise.	0.41	0.49
Market Information	Dummy: 1 = Respondent accessed formal market information (on price, standards, buyers) via extension agents, radio, or mobile phone in the last season; 0 = Otherwise.	0.41	0.49
Value of Harvest (₦)	Total monetary value (in Naira) of the cowpea harvested in the last season, based on local prevailing prices at harvest.		159,220
Sales (₦)	Total cash income (in Naira) from cowpea sales in the last season.	78,245	114,210
IDP Status	Dummy: 1 = Respondent resides in an IDP camp/settlement; 0 = Respondent resides in a host community.	0.26	0.44

Source: Authors' own editing

**RESULTS AND DISCUSSION**

**Variable description and measurement**

Table 2 revealed that providing the mean and standard deviation for each variable offers immediate insight into the sample's characteristics and the distribution of key factors. For example: The mean PPI of 40.12 provides a baseline welfare level. The mean HCI of 54.56% indicates a surprisingly high level of market participation on average, which contextualizes the discussion around distress sales. The mean household size of 7.01 and the IDP status mean of 0.26 (26%) quantify the significant consumption burdens and displacement shock highlighted in the conceptual framework as key vulnerability factors.

The description correctly frames the PPI as a tool for assessing the likelihood of living below an income poverty line. This is not only a strength for clarity but also introduces a limitation noted in the conceptual framework: the PPI is more sensitive to Pathway 1 (Income Assets) than to short-term fluctuations in Pathway 2 (Food Security). A household engaging in distress sales might use the cash for urgent needs without acquiring durable assets, showing little improvement in PPI. The negative HCI coefficient suggests this may be occurring. The study correctly interprets the PPI within its designed limits.

The Distinction Between Value of Harvest and HCI: This is the table's most methodologically important feature. By including both variables, the analysis can isolate the intensive margin of commercialization (HCI) from the extensive margin of production (Value of Harvest). The positive coefficient for Value of Harvest and negative coefficient for HCI in the integrated model would provide powerful evidence for the distress sale hypothesis: producing more is good, but being forced to sell a high proportion of what you produce is detrimental.

The binary measurement of Group Membership and Market Information is pragmatic but captures only access, not quality, intensity, or effectiveness of use. Their non-significance in the model, as discussed, could mean that mere access is insufficient without the resources to act on it—a nuance that future qualitative work could explore.

IDP Status as a Composite Shock, it is dummy variable that efficiently captures the multifaceted "contextual vulnerability"

from the conceptual framework. It is a proxy for a bundle of correlated disadvantages: loss of land, disruption of social networks, trauma, and often poorer living conditions. Its large expected negative coefficient quantifies the overwhelming impact of this compounded shock.

**Distribution of socio-economic and institutional factors of cowpea widowed farmers by displacement status**

An analysis of the socio-economic and institutional characteristics of widowed cowpea farmers (Table 3) in the IDP and host communities reveals that both groups exhibit a comparable average age (host: 49 years, IDP: 49.6 years) with similar variability. The host community demonstrates marginally higher mean years of formal education (5.18 years) in comparison to IDPs (4.79 years), exhibiting comparable variability between the two groups. The host community has slightly more farming experience (23.49 and 21.94 years respectively) and specific cowpea farming experience (15.83 and 13.53 years respectively), with similar variability between the host and IDP communities. A notable difference was in the average farm size: host community (3.41 units) and IDPs (2.23 units), suggesting that IDPs have more limited access to farmland. This disparity can be attributed to the displacement of IDPs from their original places of residence, resulting in the abandonment of their agricultural assets and other resources. The two groups demonstrate analogous levels of group membership, with both reaching approximately 41-42%. However, IDPs exhibit marginally higher access to market information (45%) compared to the host community (39%). However, the primary implication is that IDPs appear to be more constrained in terms of farm size and farming experience, and maintain larger household sizes, possibly due to displacement dynamics. Despite displacement, IDPs maintain similar levels of social integration (group membership) and slightly better access to market information. Additionally, the relatively low levels of formal education observed in both categories underscore the potential requirement for enhanced agricultural extension services. Furthermore, IDPs' larger household sizes and better access to market information may reflect their adaptive strategies in response to displacement.

**Table 3. Distribution of socio-economic and institutional factors of cowpea widowed farmers by displacement status n=525**

Variable		Age	Education	Farm size	Farming	Cowpea farming experience	Household size	Group	Market
<b>Host</b>	Mean	48.99	5.18	3.41	23.49	15.83	6.54	0.41	0.39
	Std.	13.77	5.10	2.10	12.38	9.79	2.97	0.49	0.49
		18	0	0.5	2	1	1	0	0
		80	20	14	50	50	17	1	1
<b>IDPs</b>	Mean	49.60	4.79	2.23	21.94	13.53	7.86	0.42	0.45
	Std.	14.04	4.91	1.53	12.61	10.02	2.79	0.50	0.50
		18	0	0.1	2	1	3	0	0
		80	20	7.5	50	50	17	1	1

Source: Authors' own editing

**Distribution of marketing channels of cowpea widowed farmers by displacement status**

Figure 3 represents the distribution of marketing channels used by widowed cowpea farmers, as categorized by their displacement status (host community or IDPs) and access to the market channel.

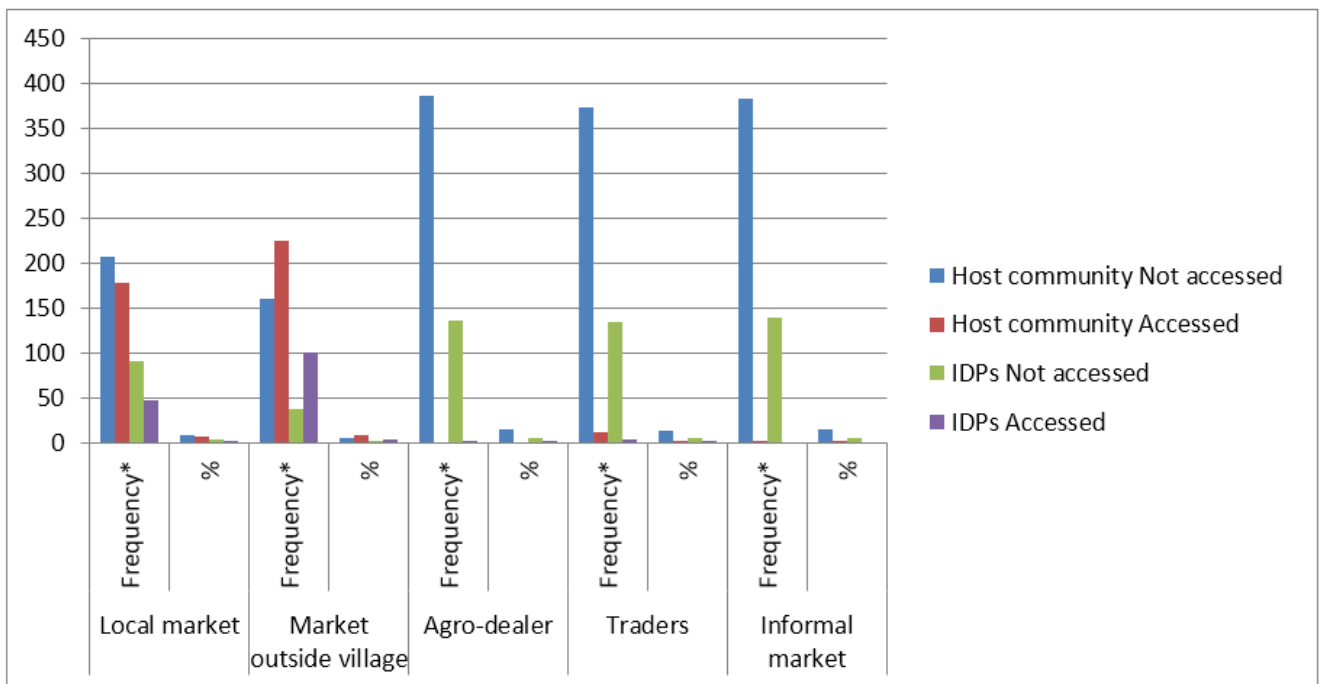
Local markets appear to be the most common marketing channel for both widowed cowpea farmers in the host community (38.6%) and IDP (14.3%), followed by markets outside the village (24.7% for host community and 15.4% for IDPs) and traders (14.25% for host community and 5.14% for IDPs).

The result further revealed that none (0%) of the IDPs surveyed accessed marketing channel from agro-dealers, and only a negligible number (0.11%) accessed from informal markets. This suggests that IDPs may face greater challenges in access-

ing essential agricultural inputs and services compared to widowed farmers in the host communities.

The figure further indicates minimal use of formal channels like agro-dealers by both host community and IDP farmers. This could be due to factors like limited access or lack of awareness about the services offered. The process of displacement can disrupt social networks, market linkages, and access to resources, making it harder for IDPs to re-establish themselves in new locations. IDPs, especially women, may face security concerns or restrictions on movement that impedes their ability to reach distant markets. IDPs often arrive in host communities with limited financial resources, making it difficult to invest in transportation, storage, or processing facilities needed to access certain markets.

**Figure 3. Marketing channels of cowpea widowed farmers by displacement status**



Source: Authors' own editing

Note: \*= multiple responses

**Household Commercialization of the widowed cowpea farmers by displacement status**

The result in Table 4 showed that the average HCI for the host community was 54.19% with a standard deviation of 16.817. This revealed that there is high market participation of widowed cowpea farmers into commercialization of cowpea with a very low dispersion within the widowed cowpea farmers.

The average mean of HCI for the IDPs was 55.44% with a standard deviation of 14.351. This revealed that there is high participation of by widowed cowpea farmers into commercialization of cowpea with a very low dispersion within them. This corroborates the findings of Shehu et al. (2024a) Shehu et al. (2024b) who found the market commercialization was high in the study area despite Boko haram insurgency, farmers-herders

conflict and incessant floods due to climate change in North-East Nigeria.

**Table 4. Market participation of the widowed cowpea farmers by displacement status n= 525**

	Variable	N	Mean	Std. Deviation	Minimum	Maximum
<b>Host community</b>	Sales (₦)	386	76,413.81	116462.33	150	1125000
	Value of Harvest (₦)	386	134,497.41	165027.37	1000	1250000
	HCI (%)	386	54.19	16.817	10	90
<b>IDPs</b>	Sales (₦)	139	83,767.55	108919.72	7500	1125000
	Value of Harvest (₦)	139	144,812.95	141557.77	20000	1250000
	HCI (%)	139	55.44	14.351	10	90

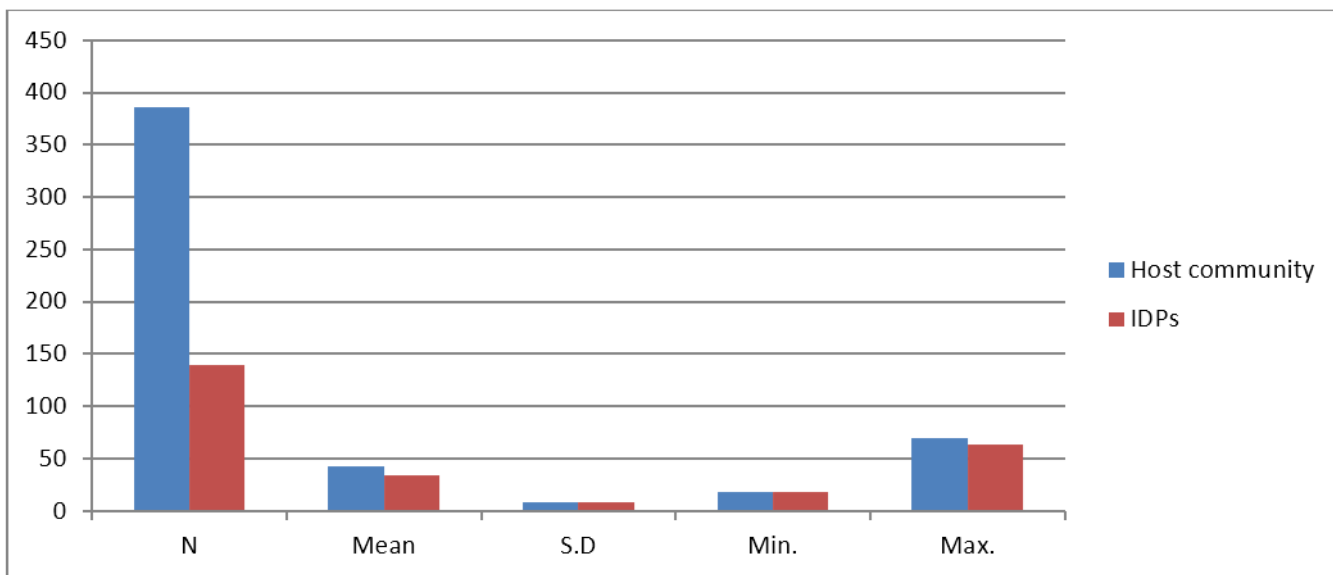
Source: Authors' own editing

**Progress out of poverty of widowed cowpea farmers by displacement status**

The result in figure 4 presents the progress out of poverty for widowed cowpea farmers, categorized by their displacement status as either host community or IDP. The average progress out of poverty score was lower for IDP farmers (33.55) compared to host community farmers (42.96). This indicates that displacement has a substantial negative effect on the ability of these farmers to escape poverty. The standard deviation for both groups is relatively low, suggesting considerable ho-

mogeneity in poverty levels among the cowpea farmers within each category. This is probably due to the fact that displacement often involves the loss of land, livestock, and other assets, making it difficult for IDPs to rebuild their livelihoods. Also, IDPs may have limited access to credit, agricultural inputs, and markets; impeding their ability to invest in productive activities. The trauma of displacement may affect the mental and physical health of IDPs, by impacting on their ability to engage in productive activities as a result of possible discrimination and social exclusion, limiting their access to opportunities and support networks.

**Figure 4. Progress out of poverty of widowed cowpea farmers by displacement status**



Source: Authors' own editing

**Factors influencing PPI of widowed cowpea farmers in North-east Nigeria**

The OLS regression results for the determinants of poverty, as measured by the Progress out of Poverty Index (PPI), are presented in Table 5. The model is statistically robust, with an F-statistic of 30.42 ( $p \leq 0.01$ ), indicating that the joint effect of the explanatory variables is significant. The model ex-

plains 35.3% ( $R^2 = 0.353$ ) of the variation in PPI scores among widowed cowpea farmers. This moderate explanatory power aligns with the conceptual framework's emphasis on the complex, multi-faceted nature of poverty, which is influenced by a broader set of socio-economic, political, and institutional factors beyond those captured here (Scoones, 1998). The analysis reveals significant relationships for several

key variables, offering insights into the pathways shaping poverty outcomes for this vulnerable group.

Consistent with the livelihood assets component of the conceptual framework, human capital in the form of legume farming experience emerged as a positive and significant ( $p \leq 0.01$ ) determinant of PPI. For each additional year of experience, a widow's PPI score increases by 0.108 points. This finding supports the literature positing that accumulated experiential knowledge enhances farmers' technical efficiency, risk management capabilities, and ability to optimize production in marginal environments typical of the North-East (Abdulsalam et al., 2024). This human capital directly strengthens a household's livelihood portfolio, facilitating progress out of income poverty.

Similarly, the total value of cowpea harvest (a proxy for the scale of production and natural capital yield) is positively associated ( $p \leq 0.10$ ) with higher PPI scores. This underscores the fundamental role of production sufficiency. A larger harvest provides a critical buffer, enhancing both food availability (subsistence pathway) and potential surplus for sale (income pathway), thereby directly contributing to improved household welfare, as found in similar contexts by Fischer and Hadju (2015). This variable's significance revealed that the absolute volume of resources, not just the proportion commercialized, is vital for poverty alleviation.

Conversely, household size exerts a strong, negative influence ( $p \leq 0.01$ ) on PPI. Each additional household member is associated with a 1.108-point decrease in the PPI score. This finding powerfully illustrates the "demands" side of the conceptual framework. A larger household size increases consumption needs and dependency burdens, stretching finite re-

sources, particularly critical for a widow managing a household alone, and limiting the capacity for savings or investment, thereby diminishing the poverty-reducing potential of any income generated (Ogwumike et al., 2013).

Most strikingly, IDP status is the strongest negative predictor in the model ( $p \leq 0.01$ ). Residing in an IDP settlement is associated with a substantial 7.760-point reduction in PPI compared to widows in host communities. This result provides robust quantitative validation for the framework's foundational element: contextual vulnerability. Displacement represents a catastrophic shock that strips households of key assets, land, livestock, permanent housing, and established social networks (IOM, 2023). The coefficient magnitude confirms that this loss of physical, natural, and social capital is so profound that it severely constrains a widow's livelihood options and significantly deepens poverty, as documented by IDMC (2021). It serves as a critical control variable, establishing the profoundly disadvantaged starting point from which IDP widows engage in commercialization.

It is instructive to note that variables such as formal education, farm size, group membership, and access to market information were not statistically significant in this model. This suggests that for widowed cowpea farmers in this crisis-affected setting, the advantages conferred by these factors may be neutralized by overarching structural constraints. For instance, the benefits of group membership (social capital) may be offset by a lack of resources to leverage collective action, or the utility of market information may be nullified by an inability to act on it due to mobility restrictions or lack of capital. This aligns with the framework's premise that in high-vulnerability contexts, the returns to certain assets are attenuated.

**Table 5. Factors influencing PPI of widowed cowpea farmers**

Variable	Coefficient	T-value
Age	-0.002 (0.027)	-0.06
Education	-0.001 (0.073)	-0.02
Farm size	-0.091 (0.186)	-0.49
Legume farming experience	0.108 (0.039)	2.77***
Household size	-1.108 (0.143)	-7.75***
Group membership	0.125 (0.671)	0.19
Market information	0.173 (0.747)	0.23
IDP status	-7.760 (0.824)	-9.42***
Value of Harvest	.0000116 (6.35e-06)	1.83*
Sales	-.0000242 (7.68e-06)	-3.15***
Constant	49.060 (2.049)	23.94
F( 10, 514)	30.420***	
R-squared	35.30%	

Note: Values in parenthesis = robust standard error

Source: Authors' own editing

#### Effects of Household commercialization on PPI

Table 6 revealed the central hypothesis of this study, derived from the dual-pathway conceptual framework, tested using the integrated OLS regression model where the House-

hold Commercialization Index (HCI) is analyzed alongside key control variables. The results of this primary analysis are presented in Table 5. The model is statistically significant ( $F(11, 513) = 22.15, p \leq 0.01$ ) and explains approximately 4.7%

of the variation in PPI scores. The coefficient for Household Commercialization Index (HCI) is -0.119 and statistically significant at the 1% level ( $p \leq 0.01$ ). Crucially, this effect is estimated while controlling for the total value of harvest, IDP status, household size, farming experience, and other covariates. This finding provides robust, nuanced evidence supporting a core pathway in the conceptual model: for widowed cowpea farmers in North-East Nigeria, a greater degree of market orientation in cowpea production is, on average, associated with a lower Progress out of Poverty Index score. Specifically, holding all other factors constant, a one-percentage-point increase in HCI predicts a 0.119-point decrease in a widow's PPI.

This result may suggest the dominance of Pathway 2 (Subsistence/Distress Channel) over Pathway 1 (Income Channel) for this specific widowed sample. The negative sign indicates that increased commercialization is correlated with worse poverty outcomes. This aligns with the framework's contingency, wherein commercialization driven by vulnerability rather than surplus can undermine well-being. For widows managing households under the strain of displacement (IDP status) and large family sizes (both significant negative predictors in this model), selling a higher proportion of their cowpea harvest likely reflects a distress sale strategy. This is undertaken to meet immediate, pressing cash needs (e.g., healthcare, debt burden, school fees), this fact may point to a distress selling mechanism at the expense of household food reserves. The resulting reduction in food availability may lead to increased expenditure on market foods later or poorer nutrition, negating any short-term cash income gains and failing to translate into the durable asset accumulation captured by the PPI. This finding empirically validates the hypothesis of Birhanu et al. (2021) regarding the poverty risks of staple crop commercialization when it compromises subsistence.

This result appears to contradict studies like Wang et al. (2024) in China and Mgomezulu et al. (2024) in more stable African contexts, which found commercialization reduced poverty. This divergence may not be a methodological discrepancy but a powerful confirmation of the conceptual framework's emphasis on contextual vulnerability. The studies finding positive effects typically analyse contexts with lower baseline vulnerability, better market infrastructure, and farmers with greater asset buffers. In contrast, our study focuses on widows in a conflict zone, a group characterized by severely diminished asset pentagons (loss of spousal support, land, and social networks). For them, the precondition for successful, surplus-based commercialization (Pathway 1) is often absent. Therefore, the observed commercialization is of a different nature—a coping mechanism rather than an entrepreneurial strategy. This perfectly illustrates De Janvry and Sadoulet's (2009) point about heterogeneity: the average effect of commercialization masks sharply different outcomes for different subgroups. Our finding clarifies that for widows in crisis settings, the common policy prescription of commercialization may be ineffective or even harmful if not preceded by interventions that address their acute vulnerability and asset deficits.

The integrated model accentuates the importance of controlling for confounding factors. The strong, persistent negative effect of IDP status and household size in this model confirms that these vulnerability factors create the conditions under which commercialization becomes detrimental. The positive effect of value of harvest remains significant, this depicts that overall production scale is beneficial, but the proportion sold (HCI) is harmful. This key distinction between selling more because you have surplus versus selling more of what you have (distress) is only visible in a model that includes both variables.

**Table 6. Effects of Household commercialization on PPI n= 525**

Variable	Coefficient	T-value
Household commercialization	-0.126*** (0.029)	-4.35
Constant	47.340 (1.660)	28.51
F( 1, 523)	18.95***	
R-squared	4.70%	

Note: Values in parenthesis= robust standard error

Source: Authors' own editing

## CONCLUSION

This study set out to interrogate the effect of household cowpea commercialization on poverty among widowed farmers in North-East Nigeria, a group situated at the critical intersection of gender, conflict, and displacement. Grounded in a revised conceptual framework that distinguishes between surplus-based and distress-driven commercialization, the analysis yields conclusions that are both nuanced and sobering.

The findings robustly demonstrate that, for this vulnerable population, a higher degree of cowpea commercialization is associated with a lower Progress out of Poverty Index (PPI) score, even after controlling for key determinants like production scale, displacement status, and household demographics.

This central result validates the dominance of Pathway 2 (the Distress Sale/Subsistence Channel) within our conceptual model. It indicates that for widows, particularly those in IDP settings or with large households' commercialization often acts as a coping mechanism rather than a growth strategy. The sale of a greater proportion of the harvest appears to be driven by immediate liquidity needs, likely at the expense of household food security, thereby failing to generate the sustainable income or asset accumulation necessary to improve their PPI-based poverty status.

The analysis further clarifies the conditions that shape this outcome. The powerful negative effects of IDP status and household size confirm that contextual vulnerability and high dependency burdens create the preconditions for detrimental

commercialization. Conversely, legume farming experience and the total value of harvest were positive factors, underscoring that human capital and production sufficiency remain foundational for welfare. The non-significance of factors like formal group membership suggests that in such high-volatile environments, the potential benefits of certain forms of social capital are neutralized without complementary resources.

Ultimately, this study concludes that the relationship between agricultural commercialization and poverty is not universal but is fundamentally mediated by initial asset endowment and vulnerability context. In the crisis-affected landscape of North-East Nigeria, promoting market participation for widowed cowpea farmers without first addressing their glaring deficits in land, security, and social protection risks exacerbating the very poverty it intends to alleviate.

### Policy Implications

Derived directly from the empirical findings and the conceptual framework, the following policy implications are proposed to guide interventions that are both effective and sensitive to the unique vulnerabilities of widowed farmers.

The strong link between IDP status and poverty necessitates policies that move beyond immediate humanitarian relief to restore productive assets. Actors rendering the humanitarian services such as government, NGOs and local community driven initiatives should facilitate formal or customary land-use agreements for widows in both host and IDP communities to rebuild natural capital. Also, they should provide direct support in the form of drought-tolerant seeds, small livestock, or simple processing equipment to help rebuild the productive asset base, creating a surplus for genuine market engagement (Pathway 1), and support widows in securing land titles, death certificates, and other legal documents to prevent asset stripping and establish economic identity.

In order to prevent commercialization from undermining subsistence, direct cash or food transfers are needed to meet urgent consumption needs. Federal government should strengthen the cash transfer program by implementing regular, predictable cash transfer programs for widowed households, particularly those with large numbers of dependents. This can reduce the pressure to sell staple food crops for emergency cash and link food assistance to activities that build community or individual assets (e.g., soil conservation, irrigation), simultaneously addressing food gaps and enhancing future productivity.

Furthermore, all the development agents present in the North-East Nigeria should consider commercialization only after subsistence is secured and should focus on creating value from genuine surplus. This could be achieved through supporting cooperatives not just for marketing, but for collective bulking, storage, and processing. This enables members to wait for favourable post-harvest prices and engage in value addition (e.g., producing cowpea flour, snacks like akara), thereby increasing income from a smaller, truly surplus quantity. Also, Connection of women's cooperatives directly to institutional buyers (schools, NGOs) for processed cowpea products, creating a more stable and remunerative market than the volatile raw grain trade could serve the purpose of subsist-

ence before commercialization.

The trauma of conflict and widowhood itself is a barrier to effective economic agency. Therefore, Psychosocial Support (PSS) and counselling should be embedded within agricultural extension and livelihood programs to help widows cope with loss and build the resilience needed for long-term planning and Train extension agents to address the specific technical, social, and mobility constraints faced by widows, offering advice tailored to their resource-limited contexts by the Social welfare department in L.G.As.

A one-size-fits-all approach will fail. The sharp disparity in poverty outcomes necessitates differentiated strategies. Therefore, widows in IDP camps and host communities should be engaged separately to design context-specific interventions by all the development actors. Federal Government and donor agencies should fund programs that foster economic integration of widows into host communities through shared resource access (e.g., communal farming plots) and conflict-resolution mechanisms to ease tensions.

### Limitation of the Study

The study had a limitation of relying on cross-sectional data. While the study tried to control for heteroskedasticity through using robust standard error, further study involving experimental or panel data designs would be needed to properly account for potential bias from unobserved heterogeneity and to test this Hypothesis. Furthermore, while the PPI is a recognized tool, it does not necessarily reflect short-term food security problems, seasonal deprivation, or nutritional losses resulting from forced sales.

### Direction for Future Studies

The study finds an association between cowpea widowed farmers' commercialization of their output and PPI, but there is need for further studies to incorporate indicators of food consumption, dietary diversity, coping strategies, debt burdens, or asset depletion, which would significantly strengthen the argument regarding forced sales.

## DECLARATIONS

### Declaration of interest statement

All the authors declare no conflict of interest.

### Declaration of Data availability

The data is with the author and would be released on reasonable request.

### Declaration of Generative AI Use

DeepAI was used to improve the grammar of the paper under the author critical thinking and evaluation, therefore the authors declare the responsibility of all the content in the paper.

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# DETERMINANTS OF UTILIZATION AND OPTIMUM USE OF FARMER FIELD BUSINESS SCHOOL RECOMMENDATIONS AMONG MAIZE FARMERS IN NORTH WEST NIGERIA

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**Abstract:** *This study examined the predictors of utilization and intensity of use of Farmer Field Business School (FFBS) recommendations among maize farmers in North West Nigeria. A structured questionnaire was administered to 231 FFBS participants in Kaduna and Kano States. Data were analysed using weighted mean scores, a Utilization Index, Probit regression for the binary utilization decision, and Tobit regression for intensity of use. Results showed that 95.7% of participants utilized FFBS recommendations, yielding a mean Utilization Index of 0.7415. Intensity of use varied widely across practice areas: planting and fertilizer application recorded the highest intensity (WM = 2.49 each), while use of Aflasafe and field measurement returned low scores (WM = 1.39 and 1.58). The Probit model identified sex ( $p < 0.10$ ), age ( $p < 0.10$ ), household size ( $p < 0.05$ ), and land acquisition mode ( $p < 0.01$ ) as significant determinants of the utilization decision. The Tobit model showed that marital status ( $p < 0.05$ ), household size ( $p < 0.10$ ), frequency of extension visits ( $p < 0.01$ ), and the Perception Index of FFBS ( $p < 0.01$ ) significantly influenced optimum use. These findings underscore the importance of targeted extension engagement and positive programme perception in deepening practice uptake among smallholder farmers.*

**Keywords:** *Farmer Field Business School, Utilization, Intensity of Use, Maize Production, North West Nigeria*  
(JEL code: O33)

## INTRODUCTION

Feeding a growing population from an increasingly constrained land base is one of the defining challenges of our time, and nowhere is this challenge more acute than in sub-Saharan Africa. In Nigeria, where agriculture provides the primary livelihood for an estimated 70 percent of the rural population and accounts for roughly a quarter of national GDP, smallholder farmers bear the greatest share of the burden (Abate et al., 2025). Yet despite decades of public investment in agricultural extension, the gap between what farmers know and what they actually do on their farms remains stubbornly wide. Understanding how to close that gap; how to move farmers from passive exposure to extension messages towards deep,

sustained application of improved practices is one of the most consequential questions in Nigerian agricultural development.

Agricultural extension services remain among the most important institutional pathways through which smallholder farmers access new production techniques, market information, and business management skills (Ojo et al., 2024). Their effectiveness, however, depends on much more than information delivery. In Nigeria, where the Agricultural Development Programme (ADP) system has historically formed the backbone of public extension, repeated reviews have pointed to chronic underfunding, inadequate numbers of extension agents, and poor follow-up as constraints on farmer-level impact (Onoja et al., 2019). Specifically, in northern Nigeria, where climatic variability is severe, input markets are often

thin, and access to formal finance remains limited, the quality of extension engagement can be a decisive factor in whether a farmer prospers or falls deeper into poverty. The challenge, however, is not simply one of reaching farmers with information. Recent scholarship has emphasised that the design of the extension model itself — the learning approach, the frequency and quality of contact, and the extent to which market and business dimensions are integrated — shapes adoption outcomes at least as much as the content being conveyed (Ojo et al., 2024). Research from across the continent has consistently shown that awareness of a recommendation and the actual adoption of it are not the same thing, and that adoption itself is not a single event but a process that unfolds with varying degrees of depth and consistency over time (Sithole & Olorunfemi, 2024).

Utilisation of agricultural extension recommendations refers to a farmer's decision to put into practice one or more of the technical, managerial, or market-related recommendations conveyed through an extension programme (Becerra-Encinales et al., 2024). In the adoption literature, this has traditionally been treated as a binary outcome: a farmer either uses a recommendation or does not. Binary choice models such as Probit and Logit have been widely applied to this question across West Africa (Abang et al., 2024; Sithole & Olorunfemi, 2024). Research across the region consistently shows that most extension participants who complete a full programme cycle do implement at least some recommendations, although uptake rates vary considerably by practice type, location, and socioeconomic context (Ragasa & Mazunda, 2018).

Intensity of utilization, by contrast, goes beyond the binary adoption decision to assess the degree of practice change. A farmer may adopt fertilizer application as a practice but apply it at the wrong rate, time, or frequency. Similarly, a farmer may engage in record-keeping only occasionally rather than as a systematic habit. Studies that capture intensity provide a richer picture of programme impact and are better placed to explain differences in productivity outcomes between participants (Teklewold et al., 2013; Manda et al., 2016; Nkosi et al., 2024). Censored regression models such as the Tobit are commonly used when the intensity variable is bounded and partially observed.

A critical distinction that has gained growing attention in the adoption literature is between the decision to utilise a practice at all and the intensity or depth with which a farmer applies that practice over time. A farmer may begin using improved seed varieties but plant them at the wrong spacing, or adopt record-keeping as a habit but fill in the register only occasionally. These differences in intensity matter enormously for productivity outcomes (Teklewold et al., 2013; Nkosi et al., 2024). A farmer who applies FFBS recommendations thoroughly and consistently derives fundamentally different benefits from one who picks up one or two easy practices and leaves the rest. Understanding the predictors of both dimensions is therefore essential for the design of more effective and better-targeted extension programmes.

The Farmer Field Business School (FFBS) is an integrated extension model that has attracted growing attention across sub-Saharan Africa as a more holistic alternative to conven-

tional extension approaches. The model combines the hands-on, discovery-based learning of the Farmer Field School (FFS) with the market literacy and business skills components of the Farmer Business School (FBS) (FAO/UN, 2019). By teaching farming, business, and market access together in a single programme cycle, FFBS is designed to address not only the agronomic constraints that limit productivity, but also the financial and commercial constraints that prevent farmers from translating higher yields into higher and more stable incomes (CARE, 2025; Wilson et al., 2026).

In Nigeria's North West, including Kaduna and Kano States, variants of the farmer school model have been implemented under several donor-supported agricultural development projects. These two states are among Nigeria's most important maize-producing zones, and the smallholder farmers who dominate production there face a complex set of challenges: erratic rainfall, degraded soils, limited access to improved inputs, and weak market linkages that mean even better harvests may not translate into better incomes. Most of the previous studies in this context have concentrated narrowly on the Farmer Field School component, with a focus on good agronomic practices for specific crops, without adequately capturing the market and business dimensions that are central to the FFBS model. Despite a growing body of evidence on FFS and FBS outcomes across sub-Saharan Africa (Davis et al., 2012; Owiredu et al., 2022; Tandane et al., 2026), there is limited quantitative analysis specifically examining the factors that determine how deeply and consistently Nigerian maize farmers apply FFBS recommendations after training.

This study addresses that gap directly. Using primary data collected from 231 FFBS participants in Kaduna and Kano States, it investigates three related questions: first, the extent to which farmers utilised the FFBS-recommended practices they were trained on; second, the intensity with which they applied those practices; and third, the socioeconomic and institutional factors that predict both outcomes. By examining utilisation and intensity as distinct but related dimensions of practice change, the study aims to generate findings that are directly actionable for extension programme managers, agricultural development practitioners, and the policymakers responsible for scaling effective approaches across northern Nigeria and beyond.

## MATERIALS AND METHODS

The study was conducted in Kaduna and Kano States in the North West geopolitical zone of Nigeria. Both states host significant maize production, and FFBS activities have been established in selected communities within each state under structured agricultural development interventions. Farmers who were active participants in FFBS groups at the time of data collection were purposively selected, targeting those who had completed at least one full season cycle of the programme. Then a total of 231 farmers were randomly selected for the study. Data were collected through structured questionnaire interviews administered by trained enumerators fluent in English and Hausa language.

Utilization of FFBS recommendations was measured as a

binary variable — whether a farmer had implemented any of the FFBS-recommended practices after training or not. Intensity of use was measured across fourteen practice areas using a three-point Likert type scale: 1 = low utilization, 2 = moderate utilization, 3 = high utilization. A weighted mean score was computed for each practice area, and a mean Utilization Index (UI) was derived by dividing the observed mean score by the maximum possible score. The decision thresholds were: low ( $\leq 1.66$ ), moderate (1.67–2.33), and high ( $\geq 2.34$ ).

Predictors of utilization were examined using two regression models. A Probit model was estimated for the binary utilization outcome (whether or not a farmer utilized FFBS recommendations), and a Tobit model was estimated for the continuous intensity of use index, which is censored on both ends. Independent variables included sex, age, marital status, household size, education level, primary income source, years in farming, land acquisition mode, farm size, frequency of extension visits, credit access, and the FFBS Perception Index. Marginal effects (dy/dx) were computed for the Probit model to facilitate interpretation. Tobit is not just a "good choice" but it is the consistent and unbiased estimator for continuous intensity doubly-censored intensity index. It respects the bounded nature of agricultural data, it corrects for truncation bias, and provides a coherent bridge between the discrete adoption decision and the continuous usage level. To ensure that there is no reverse causality, it is possible that a more favorable perception of the program increases adoption intensity, but it is equally plausible that a higher level of adoption leads to a more positive perception of the program. empirically we test the direction of the correlation, we estimated a reverse regression. While we find that intensity correlates with perception, the magnitude of the coefficient is substantially smaller than the primary model's effect, and the R-squared is dominated by exogenous farmer characteristics.

## RESULT AND DISCUSSION

### Utilization of FFBS Recommended Practices

Table 1 presents the distribution of participants by whether they utilized FFBS-recommended practices. Out of 231 respondents, 221 (95.7%) reported utilizing the recommendations, while only 10 (4.3%) did not. This high rate of utilization is broadly consistent with findings from comparable FFBS evaluations in West Africa (Owiredu et al., 2022; Adi & Tubasen, 2024) and reflects the participatory, action-oriented design of the programme, which places farmers directly in the learning environment. When farmers practise skills and observe outcomes within the same season, the barrier between knowing and doing is considerably reduced (van den Berg & Jiggins, 2007). The small proportion of non-utilizers (4.3%) suggests that structural barriers to any level of adoption are relatively low among those who have been enrolled in FFBS, which is consistent with the programme's emphasis on low-cost, farmer-friendly practices. However, the binary utilization rate alone cannot reveal whether farmers are applying recommendations thoroughly or superficially, which makes the analysis of intensity particularly important.

**Table 1. Distribution of Participants by Utilization of FFBS Recommended Practices (n = 231)**

Utilization of FFBS Recommended Practices	Frequency	%
No	10	4.3
Yes	221	95.7
Total	231	100

Source: Field Survey Data, 2024

### Intensity of Use of FFBS Recommended Practices

Table 2 presents the intensity of use of each FFBS recommendation. The mean Utilization Index of 0.7415 indicates a moderately high overall intensity of practice uptake across the programme's recommendation areas. However, significant variation exists across individual practices.

Planting and fertilizer application each recorded the highest weighted mean of 2.49, placing them firmly in the 'High' intensity category. This finding is encouraging because both practices sit at the heart of FFBS agronomic training and are directly linked to maize yield improvement. The fact that farmers apply them consistently suggests that the core production recommendations of FFBS have been successfully internalised. Harvesting (WM = 2.44) and good storage (WM = 2.40) also fell in the high intensity category, reflecting growing awareness of post-harvest losses as a significant threat to farm income — a concern that FFBS training explicitly addresses (Nakoma-Ngoma et al., 2025).

Seed selection returned a weighted mean of 2.36, also rated as high intensity. This is noteworthy because seed quality decisions are made before the season begins, and consistent high-intensity application suggests that farmers have genuinely shifted their input procurement behaviour — a more durable form of practice change than one that occurs only during the season (Mawia et al., 2025).

A cluster of practices fell in the moderate intensity range: input sourcing (WM = 2.31), use of herbicides (WM = 2.32), weeding (WM = 2.29), use of insecticide (WM = 2.26), marketing (WM = 2.26), savings (WM = 2.30), and land preparation (WM = 2.27). These results suggest that while farmers have adopted these practices, they are not yet applying them at maximum consistency or depth. The relatively moderate scores for marketing and savings are particularly worth noting, as these represent the business skill components of FFBS — areas where application requires not just knowledge but consistent habit formation and access to functioning markets and financial services (Sseguya et al., 2018).

The two practices with low intensity scores were use of Aflasafe (WM = 1.39) and field measurement (WM = 1.58). Aflasafe is a biological control product for aflatoxin contamination. Its low use intensity is likely explained by a combination of limited availability of the product in rural markets, unfamiliarity with the concept of mycotoxin management, and the perception that benefits accrue only in the medium term. Field measurement scored low despite being a foundational record-

keeping skill, possibly reflecting low confidence in numeracy and data use among a population where formal education levels are modest (Bello et al., 2024; Nyberg et al., 2025).

**Table 2. Distribution of Participants by Intensity of Use of FFBS Recommended Practices (n = 231)**

FFBS Recommendation	Low	Moderate	High	WMS	WM	Decision
Field measurement	121	174	69	364	1.5758	Low
Seed selection	8	266	270	544	2.3550	High
Input sourcing	16	254	264	534	2.3117	Moderate
Land preparation	16	272	237	525	2.2727	Moderate
Planting	15	176	384	575	2.4892	High
Use of herbicides	20	236	279	535	2.3160	Moderate
Fertilizer application	16	172	387	575	2.4892	High
Weeding	26	226	276	528	2.2857	Moderate
Use of Aflasafe	161	100	60	321	1.3896	Low
Use of insecticide	32	216	273	521	2.2554	Moderate
Harvesting	14	202	348	564	2.4416	High
Good storage	23	184	348	555	2.4026	High
Marketing	16	278	228	522	2.2597	Moderate
Savings	33	192	306	531	2.2987	Moderate

#### Mean Utilization Index (UI) = 0.7415

Note: Decision rule:  $\leq 1.66 = \text{Low}$ ;  $1.67-2.33 = \text{Moderate}$ ;  $\geq 2.34 = \text{High}$ .

Source: Field Survey Data, 2024.

#### Factors Influencing Utilization and Intensity of Use

Table 3 presents the results of the Probit regression (for the binary utilization decision) and the Tobit regression (for intensity of use). The Probit model had a Wald  $\chi^2$  (10) of 35.4 and a Pseudo  $R^2$  of 0.2091, indicating reasonable model fit. The Tobit model had an F (11, 200) of 17.37 (Prob > F = 0.000), with a log pseudolikelihood of 160.466.

Sex was positively and significantly associated with the utilization decision ( $dy/dx = 0.023$ ;  $z = 1.82$ ,  $p < 0.10$ ), suggesting that male farmers were more likely to utilize FFBS recommendations than their female counterparts. This finding is consistent with Shehu et al. (2024), Kadafur & Shehu (2023) and Kinkinginhoun et al. (2023), who found that gender-based differences in resource access, decision-making authority, and social mobility often translate into differential adoption rates in West Africa. Female farmers may face additional barriers such as limited control over land use decisions, reduced mobility to access input markets, or competing household responsibilities that constrain the time available for implementing new practices.

Age was also a positive and marginally significant predictor of utilization ( $dy/dx = 0.001$ ;  $z = 1.66$ ,  $p < 0.10$ ). This is somewhat contrary to studies that portray older farmers as more risk-averse adopters (Abate et al., 2017), but it is consistent with evidence from participatory programmes specifically where older, more experienced farmers may be more confident in evaluating the merits of a recommendation and applying it selectively where they see fit. Older farmers in the study area may also hold more authority within their households and com-

munities, giving them greater latitude to implement changes in farming practice.

Household size was negatively and significantly associated with both utilization ( $dy/dx = -0.001$ ;  $z = -2.46$ ,  $p < 0.05$ ) and intensity of use ( $dy/dx = -0.004$ ;  $T = -1.94$ ,  $p < 0.10$ ). Larger households imply greater consumption needs and a more complex internal allocation of resources. Rather than channelling additional household labour into implementing FFBS recommendations, larger families may face tighter budget constraints that limit investment in inputs, or the diffusion of decision-making across more household members may slow the adoption of new techniques (Katya et al., 2025).

Land acquisition mode was a significant negative but associated with utilization in the Probit model ( $dy/dx = -0.002$ ;  $z = -2.78$ ,  $p < 0.01$ ). Farmers who acquired land through non-ownership channels such as borrowing or renting were significantly less likely to utilise FFBS recommendations. This is consistent with Lawry et al. (2017) and Olumba et al. (2024), who identify land tenure insecurity as a major barrier to investment in productivity-enhancing practices. A tenant or borrower has limited incentive to invest labour and inputs in improving a plot from which they may be displaced, particularly for practices whose returns span multiple seasons.

Marital status was positively and significantly associated with intensity of use in the Tobit model ( $dy/dx = 0.019$ ;  $T = 2.00$ ,  $p < 0.05$ ). Married farmers may benefit from spousal labour support and shared household decision-making that facilitates deeper engagement with recommended practices (Bekele & Temesgena, 2024). This finding aligns with the broader

household economics literature, which identifies the pooling of marital resources as a positive factor in smallholder technology intensity.

The frequency of extension visits was strongly and negatively associated with intensity of use ( $dy/dx = -0.088$ ;  $T = -3.44$ ,  $p < 0.01$ ). The negative direction of this relationship is counterintuitive at first glance, but several explanations are plausible. Farmers who require more frequent extension visits may be those experiencing greater difficulty implementing recommendations. In other words, more visits may be a response to lower intensity rather than its cause. Alternatively, high-frequency visits from multiple extension systems may deliver contradictory or overlapping messages that create confusion rather than clarity. This pattern has been noted elsewhere in Nigeria (Onoja et al., 2019) and underscores the importance of coordinating extension messaging across agencies.

The FFBS Perception Index was the strongest and most significant correlate of intensity of use in the Tobit model ( $dy/dx = 0.461$ ;  $T = 5.54$ ,  $p < 0.01$ ). This is among the most important findings of the study. Farmers who had a more positive assess-

ment of the programme's effectiveness practised its recommendations more consistently and at a deeper level. This finding reinforces the theoretical proposition advanced by Meijer et al. (2015), Red et al. (2021), and Babu et al. (2025) that knowledge and attitude toward a programme are not merely antecedents of a single adoption decision but continue to correlate with ongoing practice behaviour. It also supports the conclusion that efforts to improve farmers' perception of the FFBS programme through clearer communication of results, stronger peer demonstration, and responsive facilitation are likely to yield measurable improvements in practice uptake.

Education level, primary income source, years in farming, farm size, and credit access were not statistically significant predictors of either utilization or intensity in this sample. The non-significance of education is somewhat surprising but may reflect the practical, hands-on delivery of FFBS which reduces the literacy premium on learning outcomes. The non-significance of credit access may be partly explained by the high overall utilization rate, which leaves little statistical variation in the dependent variable for the Probit model to exploit.

**Table 3. Factors Influencing Utilization and Intensity of Use of FFBS Recommended Practices (n = 231)**

Variable	dy/dx	Probit Robust Coef. (Std. Err.)	Z	dy/dx	Tobit Coef. (Robust Std. Err.)	T
Sex	0.0230	0.8336 (0.4586)	1.82*	0.0288	0.0288 (0.0256)	1.13
Age	0.0008	0.0703 (0.0424)	1.66*	-0.0002	-0.0002 (0.0012)	-0.20
Marital status	0.0000	0.0000 (0.0000)	0.00	0.0194	0.0194 (0.0098)	2.00**
Household size	-0.0010	-0.0858 (0.0349)	-2.46**	-0.0036	-0.0036 (0.0019)	-1.94*
Education level	-0.0029	-0.2567 (0.1973)	-1.30	-0.0047	-0.0047 (0.0063)	-0.74
Primary income source	0.0000	-1.0000 (8.0000)	-0.19	0.0000	0.0000 (0.0000)	0.00
Years in farming	-0.0003	-0.0226 (0.0454)	-0.50	0.0018	0.0018 (0.0012)	1.48
Land acquisition mode	-0.0024	-0.2123 (0.0764)	-2.78***	-0.0038	-0.0038 (0.0038)	-1.00
Farm size	0.0006	0.0551 (0.1648)	0.33	-0.0055	-0.0055 (0.0076)	-0.72
Frequency of ext. Visits	-0.0009	-0.0754 (0.1669)	-0.45	-0.0881	-0.0881 (0.0256)	-3.44***
Credit access	0.0000	0.0000 (0.0000)	0.00	-0.0038	-0.0038 (0.0085)	-0.45
Perception Index (PI_ FFBS)	-0.0017	-0.1532 (1.5464)	-0.10	0.4605	0.4605 (0.0831)	5.54***
Constant (_cons)		1.5166 (1.7910)	0.85		0.3832 (0.0814)	4.71
/sigma					0.1107 (0.0060)	
No. of observations	211			211		
Wald chi <sup>2</sup> (10)	35.4			—		
F (11, 200)	—			17.37		
Prob > chi <sup>2</sup>	0.001			—		
Prob > F	—			0.000		
Pseudo R <sup>2</sup>	0.2091			-0.5841		
Log pseudolikelihood	15.6798			160.466		

Note: \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1% level.  
Source: Field Survey Data, 2024.

## CONCLUSION

This study set out to examine the predictors of utilization and intensity of use of FFBS recommendations among maize farmers in North West Nigeria. The findings reveal a high overall utilization rate of 95.7%, a mean Utilization Index of 0.7415, and considerable variation in intensity across practice areas. Practices with direct, visible impact on yield (planting, fertilizer application, seed selection, and harvesting) were consistently applied at high intensity, while newer or more complex recommendations such as use of Aflasafe and field measurement lagged behind.

The regression results identify several actionable leverage points for programme improvement. First, the negative effect of large household size on both utilization and intensity suggests that extension messaging needs to engage all relevant household decision-makers, not just the primary farmer who attends FFBS sessions. Including spouses and other household members in at least selected learning events could help build broader household alignment behind the recommended changes.

Second, the negative effect of non-ownership land tenure on utilization points to a structural constraint that extension alone cannot resolve. Programmes operating in areas with high proportions of tenant or borrowed-land farmers should consider advocating for secure land access arrangements or designing practice packages that deliver visible returns within a single season, making them relevant even for farmers without long-term tenure security.

Third, the counterintuitive negative relationship between extension visit frequency and intensity of use calls for a critical review of how extension contacts are organised and coordinated. More contacts do not automatically translate into better practice uptake; the quality, consistency, and specificity of the messages delivered during visits matter more than their frequency. Reducing overlapping or conflicting messages through better inter-agency coordination would be a practical step.

Finally, and most significantly, the strong positive effect of the FFBS Perception Index on intensity of use reinforces the case for investing in activities that build and maintain positive programme perception. Farmer-to-farmer exchange visits, regular sharing of practice results within groups, and transparent feedback on agro-economic outcomes can all contribute to strengthening the attitudinal foundations of sustained practice change. Future research should explore how perceived effectiveness evolves over successive seasons, and whether formal graduation or follow-on mechanisms can sustain the engagement that drives high-intensity utilization beyond the programme period.

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# ARE AGRICULTURAL EXTENSION SERVICES ACCESSIBLE TO GHANAIAN FARMERS? PROBABILITIES AND EXPECTATIONS FROM CORNER SOLUTION RESPONSES

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**Abstract:** *Agricultural extension services play a vital role in Ghana's vegetable sector modernization and growth agenda. The Government of Ghana has made efforts to enhance extension delivery by improving the Agricultural Extension Agent (AEA)-farmer ratio from 1:1,906 in 2016 to 1:709 in 2020. However, access to extension services remains limited, raising concerns about their reach and effectiveness. This study examines the socio-economic factors influencing farmers' access to extension services in Ghana, focusing on the role of credit, farmer-based organizations (FBOs), and experience. Specifically, it analyzes the determinants of access using the Tobit model to predict probabilities and expectations associated with corner solution responses. Cross-sectional data were collected from 400 vegetable farmers across selected regions of Ghana. Findings revealed that, on average, a randomly selected vegetable farmer had about a 33% probability of accessing extension services. Key socio-economic factors influencing access included credit availability, FBO membership, household size, and farming experience. The study recommends strengthening and expanding FBOs to improve access, enhancing collaboration between government and financial institutions to facilitate credit, and providing adequate logistical and operational support to district extension directorates to ensure timely and effective service delivery across Ghana.*

**Keywords:** *Agricultural extension, Corner solution, Tobit, Conditional expectation, Unconditional expectation, Extension delivery*  
(JEL code: B41, C01, C25, Q16, Q18)

## INTRODUCTION

Vegetable cultivation remains a key source of livelihood and nutrition for many households. However, productivity is increasingly constrained by erratic rainfall, declining soil fertility, and farmers' limited knowledge of climate-resilient production technologies (Duku, Gu & Hagan, 2011; Forkuor et al., 2022). Continuous cultivation on the same land, compounded by the adverse impacts of climate change, has further degraded production systems (Mabe, Siensio & Donkor, 2014; Lassoued & Smyth, 2023). These challenges highlight the need to strengthen farmers' technical knowledge and adaptive capacity, which are often limited due to inadequate access to agricultural extension services. Extension systems play a crucial role in bridging the knowledge gap by training farmers in climate-smart practices, soil fertility management, and efficient production technologies. Strengthening these services

can therefore enhance farmers' resilience, improve productivity, and ensure the sustainability of Ghana's vegetable sector.

The primary objective of extension services is to enhance productivity, promote sustainable agricultural methods, and improve the livelihoods of farming communities through education, training, and advisory support (Priya et al., 2025). The agricultural extension system remains an important knowledge and information dissemination mechanism in developing countries because of the crucial role it plays in agricultural growth and modernization (Kaur & Kaur, 2018). Agriculture is the mainstay of most of these economies (Habineza et al., 2020), driving overall economic growth (Msuya et al., 2017). Public extension delivery services in developing countries have evolved over the years, making it imperative to focus on timely and evidence-based guidance in addressing the needs of poor and marginalized farmers. In the face of the devastating effects of climate change on agriculture, coupled with

low productivity and declining soil fertility, farmers' expectations of extension programs have become increasingly high (Danjumah et al., 2024). Agricultural extension primarily supports farmers to produce crops productively and profitably through educational interventions (Antwi-Agyei & Stringer, 2021). It bridges the gap between farm-level productivity and research station-level productivity. In developing regions like Africa, agricultural extension covers critical aspects such as agricultural production, gender inclusion, agricultural marketing, youth development, natural resource management, rural development, and leadership development (Agomoh Chisom, 2021). A key principle underlying the practice of agricultural extension in developing countries is its ability to leverage local leadership to generate a multiplier effect on the efforts of extension agents. It is inherently farmer-centered, designed to address the specific needs of farmers within their catchment areas (Agomoh Chisom, 2021). A well-functioning agricultural extension delivery system offers significant benefits to the agricultural sector. Agricultural Extension Agents (AEAs) assist farmers in accessing improved agricultural technologies for crop production (Altalb et al., 2015) and train them on how to use these technologies effectively to increase productivity. Farmers benefit more from extension delivery systems when they have frequent contact with extension officers, as this enhances their access to information on good agronomic practices that positively impact their farm businesses (Gebrehiwot et al., 2017; Acevedo et al., 2020). Various approaches employed in developing countries include demonstrations, training activities, farm visits, group discussions, farmer field schools, and plant clinics. Another important approach involves the use of media such as television and radio to deliver agricultural messages to target farmers (Jha & Singh, 2021).

## LITERATURE REVIEW

### Ghana's agricultural extension strategy

Agricultural extension remains a key driver of Ghana's agricultural sector modernization and growth agenda (MoFA, 2023). In Ghana, agricultural extension delivery services were initially started by private individuals engaged in the cocoa, coffee, and rubber value chains. After independence, the service became nationalized, leading to the establishment of the Extension Directorate in 1987 to harmonize all related services under one umbrella. The flagship extension system has been the Training and Visit (T&V) system, which has been adopted since the 1990s (MoFA, 2005). This system was largely funded by the Government of Ghana (GoG) with donor support from the World Bank. Other extension systems, such as Participatory Technology Development and Extension and the Farmer Field School approach, have also been tested in the country. The key role of Agricultural Extension Agents (AEAs) is the transfer of knowledge, which is often complemented by the facilitation of learning among farmers. In recent years, there has been increasing participation of the private sector across the entire agricultural value chain in the delivery of extension services to farmers (MoFA, 2005). The Government of Ghana has attempted to enhance extension service delivery by bridging the AEA-farmer ratio from 1:1,906 in 2016 to 1:709 in 2020

(MoFA, 2022). This improvement was achieved through the recruitment of about 2,700 extension agents in 2018 (MoFA, 2023). The initiative is expected to increase the availability of and access to technical assistance for farmers across the country so that they can achieve the highest utility from promoted agricultural programmes. However, the government's target of achieving an ideal ratio of 1:1,500 by 2025 (MoFA, 2022) remains quite large. The question, therefore, is whether farmers truly have adequate access to extension services.

Abdallah et al. (2016) recommended that the capacity of farmer-based organisations (FBOs) be strengthened to facilitate the delivery of agricultural extension services to their members, since membership in such organisations is a key determinant of access to extension services. Several other studies (Stockbridge et al., 2003; Abokyi, 2013) have also reiterated the important role FBOs play in promoting effective extension service delivery. However, since Abdallah et al. (2016) conducted their study in Northern Ghana, it is necessary to examine whether these findings can be generalised using data from Southern Ghana, where agricultural dynamics and socio-economic contexts may differ. Farmer-based organisations serve as business models that can support the adoption of climate-resilient technologies. For instance, farmers' cooperatives, a form of FBO, enable members to pool their resources for production and marketing. These cooperatives have been instrumental in helping vegetable farmers adopt irrigation systems in Ghana (Owusu, 2021). In rural parts of the north, where vegetable production has been severely affected by erratic rainfall, cooperative societies have allowed farmers to mobilize resources to establish irrigation systems. This has enabled them to produce vegetables all year round, thereby building resilience to the adverse impacts of climate change (Owusu, 2021).

Socio-economic characteristics also influence both access to and receipt of extension services. Age and education, for example, affect the extent to which farmers receive such services (Atsan et al., 2009). Older farmers tend to receive fewer extension visits because they are often conservative and less receptive to new innovations. Conversely, higher education levels positively affect access to extension services, as education enhances understanding of the importance and benefits of adopting new technologies. With respect to access to extension services, Abdallah et al. (2016) further identified age and farm size as factors that affect access to credit, which indirectly influences participation in extension activities. Understanding how socio-economic characteristics shape farmers' participation in extension services is therefore critical for designing inclusive and effective agricultural support systems. This present study examines the factors affecting access to agricultural extension services in Ghana. Specifically, it seeks to measure the response probabilities and expectations associated with the number of extension visits farmers receive. The study contributes to existing literature in two key ways. Firstly, it predicts the average response probabilities of accessing extension services. Secondly, it measures partial effects under both conditional and unconditional expectations and compares these effects at the levels of Average Partial Effect (APE) and Partial Effect on the Average (PEA).

**MATERIALS AND METHODS**

**Theoretical and empirical models**

Crop farmer’s access to agricultural extension services can be roughly described as a corner solution response if it is measured as the number of extension visits received during the production season. In a population of farmers, the dependent variable (number of extension visits received during the production season) takes on a wide range of values which is zero for some significant fraction. Corner solution responses can be analyzed using the tobit model (Wooldridge, 2016). Other limited dependent variable models like logit and probit cannot be used to model the number of extension visits because they take on only binary responses. The tobit model is defined by the latent variable  $y^*$  :

$$y^* = x\beta + e, \quad e \sim N(0, \sigma^2)$$

$$y = y^* \cdot 1[y^* > 0]$$

Where  $1[\ ]$  is the indicator function which returns a 1 if the expression in  $[ \ ]$  is true, and 0 otherwise. In the tobit model, we assume that the error term follows a standard normal distribution with mean and standard deviation equal to 0 and  $\sigma^2$  respectively. The values of interest in the tobit model include: (1) Probability of extension service access (2) Conditional expectation, (3) Unconditional expectation and (4) Partial effect for the respective values of interest (Smed et al., 2017; Wooldridge, 2016).

**Probability of receiving extension service and associated average partial effect (APE)**

Given that the probability of observing a zero,

$$P(y = 0) = 1 - \Phi\left(\frac{x\beta}{\sigma}\right) \quad (1)$$

in the case of number of extension visits received by farmers (i.e. not receiving extension services).

The probability of having a positive value (number of extension visits) is therefore presented as:

$$P(y > 0) = \Phi\left(\frac{x\beta}{\sigma}\right) \quad \text{Where}$$

**$\Phi$  is the standard normal cdf**

For a discrete variable, the average partial effect is given as:

$$\frac{1}{N} \sum_{i=1}^N \frac{\Delta P(y>0)}{\Delta x_k} = \frac{1}{N} \sum_{i=1}^N \left( \Phi\left(\frac{x_{c+1,i}\beta}{\sigma}\right) - \Phi\left(\frac{x_{c,i}\beta}{\sigma}\right) \right) \quad (2)$$

For a continuous variable, the average partial effect is given as :

$$\frac{1}{N} \sum_{i=1}^N \frac{\partial P(y > 0)}{\partial x_k} = \frac{1}{N} \sum_{i=1}^N \left( \phi\left(\frac{x_i\beta}{\sigma}\right) \left(\frac{\beta_k}{\sigma}\right) \right) \quad (3)$$

Conditional expectation  $E(y|y>0)$  and associated average partial effect (APE)

In the tobit model,  $(E(y|y>0))$  is the expected value for those having a positive value (Wooldridge, 2016). In this study the expected value is the number of extension visits received by a farmer who had positive extension visits from AEAs (i.e.

$$E(y|y > 0) = x\beta + \sigma\lambda\left(\frac{x\beta}{\sigma}\right) \quad (4)$$

For a discrete variable, the average partial effect is given as:

$$\frac{1}{N} \sum_{i=1}^N \frac{\Delta E(y|y > 0)}{\Delta x_k} = \frac{1}{N} \sum_{i=1}^N \left( \left( x_{c+1,i}\beta + \sigma\lambda\left(\frac{x_{c+1,i}\beta}{\sigma}\right) \right) - \left( x_{c,i}\beta + \sigma\lambda\left(\frac{x_{c,i}\beta}{\sigma}\right) \right) \right) \quad (5)$$

For a continuous variable, the average partial effect is given as :

$$\frac{1}{N} \sum_{i=1}^N \frac{\partial E(y|y > 0)}{\partial x_k} = \frac{1}{N} \sum_{i=1}^N \beta_j \left\{ 1 - \lambda\left(\frac{x\beta}{\sigma}\right) \left[ \frac{x_i\beta}{\sigma} + \lambda\left(\frac{x\beta}{\sigma}\right) \right] \right\} \quad (6)$$

**Unconditional expectation E(y) and associated average partial effect (APE)**

In the tobit model, unconditional expectation  $E(y)$  refers to the expected value of  $y$  for both those with zero and positive values. In the case of this article average number of extension visits that a farmer in the population received from AEAs in the whole season. This is equal to the probability of having a positive value times the expected value given the farmer has positive values. In this case the probability of being visited time the number of visits, given a farmer was visited by an AEA. Unconditional expectation can be expressed as:

$$E(y) = P(y > 0) \cdot E(y|y > 0|x) = \Phi\left(\frac{x\beta}{\sigma}\right) x\beta + \sigma\phi\left(\frac{x\beta}{\sigma}\right) \quad (7)$$

For a discrete variable, the partial effect is given as:

$$\frac{\Delta E(y)}{\Delta x_k} = E(y|x_1, \dots, x_k = c + 1) - E(y|x_1, \dots, x_k = c) \quad (8)$$

$$= \left[ \Phi\left(\frac{x_{c+1}\beta}{\sigma}\right) x_{c+1}\beta + \sigma\phi\left(\frac{x_{c+1}\beta}{\sigma}\right) \right] - \left[ \Phi\left(\frac{x_c\beta}{\sigma}\right) x_c\beta + \sigma\phi\left(\frac{x_c\beta}{\sigma}\right) \right] \quad (9)$$

We calculate the partial effect for every farmer and take the average (Smed et al., 2017). For a continuous variable, the partial effect is also given as :

$$\frac{\partial E(y)}{\partial x_k} = \beta_k \Phi\left(\frac{x\beta}{\sigma}\right) = \frac{\partial p(y > 0)}{\partial x_k} E(y|y > 0) + p(y > 0) \frac{\partial E(y > 0)}{\partial x_k} \quad (10)$$

Here we also calculate the partial effect for every farmer and take the average for the APE (Smed et al., 2017).

A formal representation of the tobit model with number of extension visits explained by the independent variables is

$$y^* = \beta_0 + \beta_1 gender + \beta_2 education + \beta_3 off_{farm} + \beta_4 credit + \beta_5 fbo + \beta_6 household\ size + \beta_7 age + \beta_8 age_{squared} + \beta_9 experience + \beta_{10} farmsize + e \quad (11)$$

$e \sim N(0, \sigma^2)$   
extension visits =  $y^* \cdot 1[y^* > 0]$

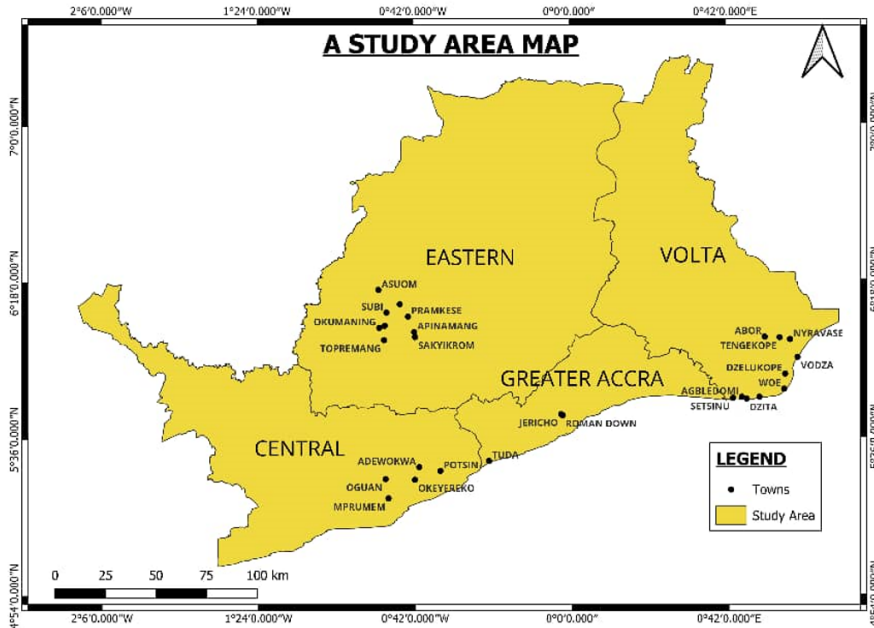
**Data collection and analysis**

A cross sectional data collected from vegetable farmers was employed for this study. The dataset is from a 2023 survey that was carried out in the Central, Eastern, Volta and Greater Accra regions of Ghana. A two-stage sampling technique was employed in the selection of respondents across different ecological and socio-economic zones. In the first stage, four regions—Central, Eastern, Volta, and Greater Accra—were

purposely selected based on their significance in vegetable production, diversity in agro-ecological conditions, and varying levels of access to extension services. These regions also reflect a mix of coastal, forest, and transitional zones, which provide a broader understanding of the dynamics influencing agricultural

extension service delivery in southern Ghana. In addition, eight districts were also selected purposively within the four regions namely: Gomoa East, Gomoa West, Kwaebibirem, Denkyem-bour, Weija, Kpone-Katamanso, Anloga and Keta. The second stage was a random selection of 50 vegetable farmers from each

Figure 1. Map of Study Area



Source: Own editing

Table 1. Sample size distribution

Region	District	Sample frequency
Central	Gomoa West	50
	Gomoa East	50
Eastern	Kwaebibirem	50
	Denkyembour	50
Greater Accra	Weija	50
	Ashaiman	50
Volta region	Anloga	50
	Keta	50
Total		400

Source: Own editing

district, yielding a sample size of 400 farmers.

The dataset comprises information on the number of times farmers were visited by agricultural extension agents in the last vegetable production season for 2022/23 crop season. Other information collected include socio-demographic status of farmers and their off-farm work information. The dependent and independent variables that were used in the tobit model are presented in Table 2. The independent variables were classified

as discrete and roughly continuous variables. The discrete variables included gender, education, off-farm income and credit. Household size, age, age squared, experience and farm size were also classified as roughly continuous variables. Questionnaires for data collection were administered to the study respondents from July 2023 to September 2023. KoboCollect mobile application, a computer-assisted personal interviewing software, was employed for data collection. The Excel software was employed for data-cleaning and descriptive analysis. The

**Table 2. Description of the variables in the dataset**

Variable	Variable name	Description
<i>Dependent</i>		
Extension access	Extension visits	A corner solution response variable. It is the number of times AEAs visited the farmer’s farm during the crop production season.
<i>Independent</i>		
Gender	Gender	= 1 if respondent is male, 0 otherwise
Educational level	Education	= 1 if respondent received JHS education, 0 otherwise
Credit	Credit	= 1 if respondent received credit, 0 otherwise
FBO	FBO	= 1 if respondent was a member of an FBO, 0 otherwise
Age	Age	Continuous variable: age
Household size	Household size	Continuous variable: Number of people in household of the respondent
Experience	Experience	Continuous variable measured in years of farming
Farm size	Farm size	Continuous variable measured in hectares

Source: Own editing

study employed R software for the regression analysis.

## RESULTS AND DISCUSSION

### Personal characteristics of the respondents

In Table 3, the distribution in terms of age, farm size, years of farming and household size of farmers is presented. The total number of respondents was 400. The average age of the farmers was approximately 45 years, indicating that most of them are economically active, an assertion supported by the findings of Gelgo et al. (2016). The average number of years farming was about 13, indicating that on the average vegetable farmers have been in the farming business for more than a decade as a means of livelihood. Farmers who have spent more years in farming usually have a better understanding of how the various technologies can be applied for better outcomes. They have more

technical knowledge in the application of the climate-resilient technologies (Donkoh et al., 2019). Similar findings are also reported in a study by Jordan et al.(2021), where majority of smallholders had acquired more than a decade of experience in the farming business. The average household size of the farmers was approximately six members. This is very important in providing family labor for vegetable farming where the supply of hired labor is low (Beshir et al., 2022).

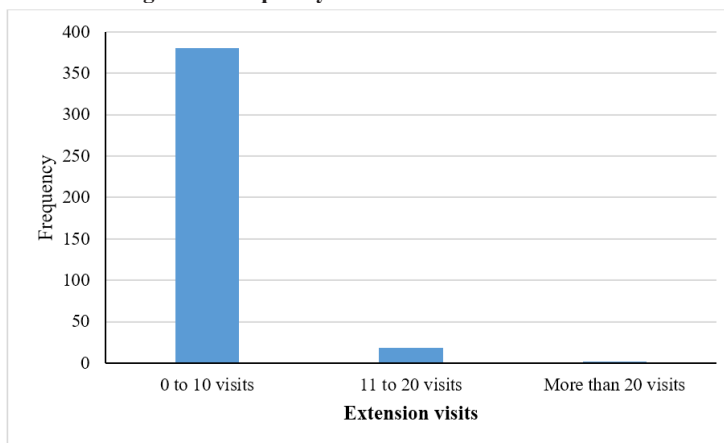
Figure 2 presents the distribution of the number of extension visits received by farmers within the study area. The results reveal that a vast majority of farmers (95%) received between 0 to 10 visits from Agricultural Extension Agents (AEAs) during the crop production season. This indicates limited interaction between farmers and extension officers, which could negatively affect the timely dissemination of agricultural information and

**Table 3. Socio-economic characteristics of the respondents by mean**

Category	Mean	Standard deviation
Age	45.46	12.90
Farm size	0.63	0.53
Years of farming	13.23	11.28
Household size	6.04	2.92

Source: computation from survey data, 2023

**Figure 2. Frequency distribution of extension visits**



Source: Own editing

adoption of improved practices.

A small proportion of respondents (4.7%) reported receiving 11 to 20 visits, while only 0.25% had more than 20 visits during the production season. The low number of farmers receiving frequent visits suggests that extension delivery remains constrained, possibly due to an inadequate extension-to-farmer ratio, logistical challenges, or resource limitations within the extension system. Overall, the findings highlight a significant gap in extension contact frequency, underscoring the need for strengthening extension service delivery to ensure farmers receive adequate technical support and advisory services necessary for improving productivity and resilience in agricultural production.

**Probabilities of receiving extension services, Conditional and Unconditional expectations**

**Table 4. Probabilities, Conditional and Unconditional expectations**

	Minimum	Maximum	Mean
P(y>0)	0.0574	0.7967	0.3285
E(y y>0)	3.735	10.355	5.787
E(y)	0.2142	8.2491	2.0634

Source: Own editing

Table 4 also indicates that mean unconditional expectation E(y) was approximately two. Unconditional expectation is the expected value of extension services for both farmers with zero and positive values. The minimum and maximum values were

A distribution of the predicted probabilities of receiving extension and expected values from the tobit estimation is presented in Table 4. The  $\beta$  coefficients from the tobit estimation are presented with p-values in Table 5. Finally results for both average partial effects (APEs) and partial effect on the averages (PEAs) are reported for the three values of interest (probability, conditional and unconditional expectations), also in Table 5. Results from table 4 indicates that mean probability of receiving extension services P(y>0) was approximately 33%. The minimum and maximum probabilities were 6% and 80% respectively for the farmers in the study area. The table indicates that mean conditional expectation E (y|y>0) was approximately six. Conditional expectation is the expected value for those who had positive number of extension visits from the AEAs. The minimum and maximum values were approximately four and ten respectively.

approximately 0.2 and eight respectively.

**Partial effects: APEs and PEAs**

Table 5 shows both APEs and PEAs for the tobit model. Partial effect is the estimated change in the three values of interest when the value of one of the explanatory variables changes by one unit. The tobit regression results shows that the effect of

**Table 5. Regression results from the tobit model**

Variable	Estimate	Pr(> Z )	APE			PEA		
			P(y>0)	E(y y>0)	E(y)	P(y>0)	E(y y>0)	E(y)
(Intercept)	-7.3733	0.0064**						
Gender	2.0154	0.1369	0.0747	0.5451	0.6192	0.0794	0.5286	0.5947
Education	0.7058	0.5519	0.0269	0.2002	0.2352	0.0289	0.1936	0.2267
Credit	4.2314	0.0008***	0.1713	1.2809	1.5799	0.1805	1.2534	1.5519
FBO	4.3907	0.0001***	0.1757	1.2740	1.5350	0.1828	1.2515	1.5072
Household size	-0.5056	0.0135*	-0.0209	-0.1721	-0.2224	-0.0228	-0.1670	-0.2210
Age	-0.0043	0.9385	-0.0002	-0.0012	-0.0014	-0.0002	-0.0012	-0.0013
Experience	0.1014	0.0823.	0.0038	0.0285	0.0333	0.0041	0.0276	0.0320
Farm size	1.3233	0.1997	0.0501	0.3721	0.4347	0.0538	0.3597	0.4179

Scale: 8.74 ; Wald-statistic: 42.01 on 8 Df, and p-value: 1.3473e-06

Log-likelihood: -627.1 on 10 Df

Notes: “\*\*\*\*” means p-values in the range of 0%- 0.1%; “\*\*\*” means p-values in the range of 0.1% - 1%; “\*\*” means p-values in the range of 1% - 5% and “.” means p-values in the range of 5% - 10% [n =400]

Source: Own editing

credit, FBO membership, household size and experience were the only significant variables in the model.

The squared correlation, a goodness of fit measure for the tobit, was estimated to be approximately 0.0624. This smaller value is normally the case for Limited dependent variables which in this case is a tobit model, employed to model cross-sectional data. This is because tobit estimates are selected to maximize the log-likelihood function and not the R-squared. The Wald test, also an overall fit measure of the model, was statistically significant with a test statistics of 42.01. This means the independent variables were jointly significant in explaining the variance in extension visits compared to reduced form models. A limitation of the study is that we did not analyze other dependent variables like distance to extension offices, infrastructure availability or road quality which also predict extension access. The focus of the study was to analyze socio-economic characteristics of the farmers that predict access to extension services.

### Credit

The Average Partial Effect (APE) represents the estimated change in the outcome variable based on each respondent's characteristics, averaged across all observations. In this study, the APE of credit on the probability of receiving extension services,  $P(y>0)$ , was 0.1713, implying that farmers who received credit were approximately 17 percentage points more likely to access extension services—a relationship that was highly significant at the 0.1% level. Similarly, the APE of credit on the conditional expectation,  $E(y|y>0)$ , was 1.2809, indicating that among farmers who had at least one extension contact, access to credit was associated with about 1.28 additional visits per year. The APE on the unconditional expectation,  $E(y)$ , was 1.5799, suggesting that farmers with access to credit were expected to receive, on average, nearly two more visits annually, regardless of whether they initially had extension contact.

The Partial Effect at the Average (PEA) is the partial effect calculated using the values of the average "respondent" in the dataset (Wooldridge, 2016). The PEA of credit on the probability of receiving extension services was 0.1805. The PEA on the conditional expectation was 1.2534, while that on the unconditional expectation was 1.5519. These results indicate that farmers were about 18% more likely to be visited by extension officers if they received credit, given that the partial effect was calculated at mean values. The change in the conditional expectation when farmers had access to credit was 1.2534, whereas the change in the unconditional expectation was 1.5519.

Access to credit plays a crucial role in enhancing farmers' engagement with extension services. Credit enables farmers to afford inputs, technologies, and logistics that attract the attention of extension officers. Such farmers are often perceived as more productive and capable of effectively implementing new practices. Consequently, those who obtain credit are more likely to receive follow-up visits and technical assistance from extension officers, as they represent promising beneficiaries for agricultural development programs. These results highlight the vital role of credit in enhancing both access to and frequency of extension services. Access to financial resources enables farmers to invest in recommended technologies and inputs, making

them more receptive to and engaged with extension activities (Moahid et al., 2021; Owusu, 2017).

### FBO membership

The Average Partial Effect (APE) of FBO membership on the probability of receiving extension services was 0.1757. The effect of FBO membership was significant at the 0.1% level, implying that the probability of receiving extension services increased by approximately 18% if a farmer was an FBO member. The APEs of FBO membership on the conditional and unconditional expectations were 1.2740 and 1.5350, respectively. This indicates that farmers who were members of an FBO were expected to receive about one additional visit if they had access to extension services during the crop season. Furthermore, a farmer who was a member of an FBO was also expected to receive approximately two more visits, irrespective of whether he or she was initially visited during the season.

The Partial Effect at the Average (PEA) provides a complementary perspective, as it measures the partial effect evaluated at the mean values of the explanatory variables. The PEA of FBO membership on the probability of receiving extension services was 0.1828, while the PEAs on the conditional and unconditional expectations were 1.2515 and 1.5072, respectively. These results suggest that, on average, farmers who were members of an FBO were about 18% more likely to be visited by extension agents compared to non-members. Similarly, access to FBO membership was associated with an expected increase of 1.25 extension visits among those already receiving services and about 1.51 additional visits overall.

FBOs facilitate access to agricultural extension services through lobbying, advocacy, and the provision of resources that enhance the effectiveness of extension officers (Akomaning et al., 2017). As collective organizations, they serve as vital platforms connecting farmers to extension systems by coordinating training, mobilizing members, and facilitating communication between farmers and extension officers (Abdallah et al., 2016). FBOs have a mandate to ensure that their members are adequately informed about good agricultural practices and often act as intermediaries for extension delivery. Through these functions, members benefit from group-based extension visits, demonstrations, and capacity-building activities organized through their associations. Consequently, farmers who belong to FBOs are more likely to receive follow-up visits and technical support from extension agents, as such membership strengthens their linkages with agricultural service providers (Ahmed, 2019; Ibrahim et al., 2025). Since being in an FBO can increase the on the probability of receiving extension services, FBOs' capacity can be built to facilitate the delivery of agricultural extension services to their members as mentioned by Stockbridge et al. (2003), Abokyi (2013) and Abdallah et al. (2016).

### Household size

The Average Partial Effect (APE) of household size on the probability of receiving extension services was -0.0209. This indicates that the probability of receiving extension services decreased by approximately 2.1% if the number of members in a respondent's household increased by one. The effect of household size was significant at the 5% level. The APE on the conditional expectation was -0.1721, while the APE on the un-

conditional expectation was -0.2224. This suggests that farmers from larger households were expected to receive almost no additional extension visits if only they were visited during the crop season. Similarly, a farmer with a larger household was expected to receive approximately no extra visits, regardless of whether they initially had access to extension services.

The Partial Effect at the Average (PEA) provides an additional perspective, measuring the effect at the mean values of the explanatory variables. For an increase in household size by one member, the PEA on the probability of receiving extension services was -0.0228, while the PEAs on the conditional and unconditional expectations were -0.1670 and -0.2210, respectively. These results indicate that as household size increases by one member, the likelihood of receiving extension services decreases by roughly 2.3%, and the expected number of extension visits declines correspondingly, whether or not the farmer already receives such services.

This negative relationship may be attributed to the increased financial and logistical responsibilities associated with larger households. Farmers with many dependents often face competing demands that limit their ability to afford costs associated with extension visits or to provide the inputs and logistics necessary for effective engagement with extension officers (Daniel & Teferi, 2015). As a result, extension officers may be less inclined to visit these farmers, given the perception that they have limited capacity to implement recommended technologies or adopt advisory guidance. Consequently, larger household size appears to reduce both the likelihood and frequency of extension service delivery to farmers.

### Years of farming

The probability of receiving extension services increased by approximately 0.4% for each additional year of a farmer's experience. The Average Partial Effect (APE) on the conditional and unconditional expectations was approximately 0.03, indicating that as farmers gain more experience, they are slightly more likely to receive extension visits. Experienced farmers often adopt improved agricultural technologies that require technical knowledge and assistance from district extension directorates. Consequently, they are more likely to request and benefit from additional visits from extension officers (Anang & Asante, 2020).

The Partial Effect at the Average (PEA) further supports this finding. For a one-year increase in farming experience, the PEA on the likelihood of receiving extension services was estimated at 0.0041, while the PEAs on the conditional and unconditional expectations were 0.0276 and 0.0320, respectively. These values, calculated at the means of the covariates, suggest that each additional year of experience slightly increases the probability of receiving extension services and the expected number of visits, whether or not farmers already have access to such services (Wooldridge, 2016).

This positive association may be explained by the greater awareness and proactivity of experienced farmers in seeking technical advice. They are often engaged in innovative farming practices and more willing to adopt improved technologies, which require guidance from extension officers. As a result, ex-

ension agents may prioritize these farmers for visits, recognizing their commitment to improving productivity and effectively implementing new agricultural practices.

## CONCLUSION

Previous studies in agricultural extension access in Ghana have not highlighted the different ways by which the partial effects associated with probabilities and expectations can be evaluated. The present study predicts response probabilities and includes a broad range of assessing partial effects for the conditional and unconditional expectations. The findings of the study imply that on average, a randomly selected farmer had about 33% chance to access extension services in the study area. The average visits received by the farmers, given extension access, was estimated to be approximately six in the season. The findings also imply that the average visits received unconditionally were estimated to be two in the season. The socio-economic factors that were found to influence farmers' access to extension services were credit, FBO membership, household size and experience. Farmers were more likely to receive extension support if partial effects were measured using the average value of an individual in the dataset. The study also demonstrated that the average number of visits received by farmers was larger when partial effects for both expectations of interest are calculated using the APE method. The study recommends the intensification of the formation of farmer-based organisations to improve extension access in Ghana. Also, capacity building of FBO to facilitate the delivery of agricultural extension services to members can fill the gap created by low extension access. Also, the government of Ghana should team up with credit institutions to improve the intermediation among farmers. Lastly, stakeholders in the agriculture sector should assist the district extension directorates with the needed logistics to make their work effective.

### Disclosure Statement

The authors report there are no competing interests to declare

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# DECODING THE BLOCKCHAIN PRODUCTIVITY PARADOX IN SMES: A QUALITATIVE INVESTIGATION OF COGNITIVE BARRIERS AND INSTITUTIONAL PRESSURES

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**Abstract:** While blockchain technology (BCT) has emerged as a disruptive force capable of redefining trust and transparency in global supply chains, its adoption among Small and Medium-Sized Enterprises (SMEs) remains low, resulting in a digital productivity paradox. Existing literature predominantly attributes this technological lag to financial constraints and complex technical requirements. This study challenges the traditional cost-centric paradigm by exploring the underlying cognitive, organizational, and institutional factors driving SME decision-making. Utilizing a qualitative, exploratory research design, 22 semi-structured in-depth interviews were conducted with strategic decision-makers across five SME sectors in Hungary. The theoretical framework synthesized the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), and Institutional Theory. An innovative "negative proof" thought experiment, assuming 100% external funding was applied to rigorously isolate cognitive barriers from financial constraints. The findings reveal that the primary barrier to adoption is a fundamental cognitive gap: the lack of technological awareness, profound fears regarding transparency (e.g., GDPR conflicts, trade secrets), and exceptionally low perceived business usefulness. Furthermore, SME innovation strategies regarding decentralized networks are structurally reactive. Adoption intentions are almost exclusively driven by coercive institutional isomorphism, specifically, the mandates of dominant multinational partners and regulatory compliance, rather than internal innovativeness. These insights emphasize that BCT must be treated as a socio-technical system, necessitating proactive mentoring from large corporate integrators and targeted regulatory frameworks to bridge the technological divide.

**Keywords:** Blockchain Adoption, Small and Medium-sized Enterprises (SMEs), Technology Acceptance Model (TAM), Institutional Theory, Cognitive Barriers, Productivity Paradox.  
(JEL code: O31, O33, M15)

## INTRODUCTION

The global economy of the twenty-first century is undergoing a profound digital transformation driven by the exponential spread of Fourth Industrial Revolution technologies (Schwab, 2017). Within this paradigm shift, blockchain technology (BCT) has emerged from the shadow of cryptocurrencies to become a potential key driver of corporate competitiveness, fundamentally rewriting the concept of trust in the global economy (TAPSCOTT & TAPSCOTT, 2016). According to traditional institutional economics, economic exchange processes involve significant transaction costs stemming from a lack of trust, information asymmetry, and the need to enforce contracts through costly intermediaries (North, 1990). Blockchain promises to minimize these agent costs and frictions by providing a decentralized, immutable, and transparent distributed ledger (CASEY & VIGNA, 2018).

Despite these theoretical advantages, the corporate adop-

tion of blockchain is increasingly characterized by a "productivity paradox" (NAGY ET AL., 2025). Enterprises invest substantial resources into blockchain developments, yet the expected financial returns and efficiency gains often materialize with significant delay, or fail to manifest entirely, placing many blockchain solutions in the "trough of disillusionment" (GARTNER, 2023). The paradox between the theoretical promise and practical business reality highlights a critical gap, where the initial implementation costs often overshadow short-term profitability (SWAN, 2015; CASATI ET AL., 2024).

The mentioned productivity paradox and the resulting technological gap become particularly evident within the Small and Medium-Sized Enterprise (SME) sector. While multinational corporations possess the resources and R&D capacities to experiment with BCT, the SME sector faces a severe technological lag that poses a critical risk to their integration into global value chains (JACKSON & ALLEN,

2024; CHOTIA ET AL., 2025). Although the existing scientific discourse has extensively applied frameworks such as the Technology-Organization-Environment (TOE) and the Technology Acceptance Model (TAM) to evaluate adoption barriers, research focusing specifically on the Central and Eastern European (CEE) region, and particularly on the cognitive and institutional constraints of Hungarian SMEs, remains scarce (WONG ET AL., 2020). Prevailing studies frequently cite high costs as the primary obstacle for SMEs; however, psychological approaches suggest that decision-maker attitudes, such as the lack of technological awareness and low perceived usefulness, may play an equally decisive role (DAVIS, 1989; PARASURAMAN, 2000).

Therefore, the primary objective of this qualitative study is to investigate the underlying realities of blockchain adoption within the domestic SME ecosystem. Based on the identified research gaps and the integration of the Technology Acceptance Model with Institutional Theory, this study formulates and tests the following two primary hypotheses:

- Hypothesis 1 (H1): The primary barrier to blockchain adoption within the SME sector is not technological complexity or financial constraints, but rather a fundamental cognitive gap, characterized by the lack of technological awareness and a low level of perceived business usefulness.

- Hypothesis 2 (H2): The intention of SMEs to adopt blockchain technology is driven predominantly by external institutional pressures (coercive mandates from dominant partners or regulatory bodies) rather than internal organizational innovativeness or proactive strategy.

## LITERATURE REVIEW

### The Foundational Nature of Blockchain and the Productivity Paradox

The literature increasingly emphasizes that blockchain is not merely a disruptive, plug-and-play cost-reduction tool but a "foundational technology" whose economic benefits are realized indirectly through the establishment of data integrity and organizational trust (IANSITI & LAKHANI, 2017). Similar to the evolution of the TCP/IP protocol, the true value of BCT requires an ecosystem-level transformation over a longer time horizon (CASATI ET AL., 2024). This foundational nature explains the "Blockchain Productivity Paradox" observed in the early adoption phases: high initial implementation costs, complex maintenance, substantial energy requirements, and the need for specialized human capital often overshadow short-term profitability (KOUHIZADEH ET AL., 2021; NAGY, 2025; GÜRPINAR ET AL., 2025).

Furthermore, the paradox is deepened by the theoretical concept of "trustless trust." BCT supposedly eliminates traditional intermediaries by transferring trust to cryptographic codes and consensus mechanisms (BISWAS & GUPTA, 2019; PATHAK ET AL., 2025). However, as Meyers & Keymolen (2023) note through the concept of "functional fiction," trust does not disappear; it merely shifts from human intermediaries to technological experts and software, creating new forms of information asymmetry and vulnerability for non-technical users. Additionally, the "Garbage In, Garbage Out" (GIGO)

phenomenon and the "Oracle problem" demonstrate that blockchain only guarantees the integrity of data once it is on the ledger; it cannot verify the truthfulness of physical inputs, necessitating the integration of IoT sensors and maintaining a certain degree of institutional trust (CALDARELLI, 2020; HASSAN ET AL., 2024). Consequently, the cost-efficiency gains only emerge when the technology successfully mitigates ex-post opportunism and agency costs within a mature and reliable network (JEANNERET ET AL., 2024).

### Individual and Organizational Technology Acceptance Models (TAM, UTAUT, TRI)

Understanding SME adoption requires analyzing individual cognitive attitudes and organizational readiness. The Technology Acceptance Model (TAM) identifies Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) as the primary determinants of behavioral intention (DAVIS, 1989; ALTAMIMI ET AL., 2024). In the context of blockchain, PU is highly dependent on clear advantages such as transparency and transaction speed (HAMADEH ET AL., 2025). However, the inherent complexity of BCT, such as managing private keys and understanding cryptographic hashes often negatively impacts PEOU, creating a significant cognitive barrier (OBIDALLAH ET AL., 2024). If the system requires excessive cognitive effort, users tend to rely on familiar, centralized solutions like SQL databases (MALIK ET AL., 2021; DEGHANI ET AL., 2022).

The Unified Theory of Acceptance and Use of Technology (UTAUT) incorporates Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions (VENKATESH ET AL., 2003; AL-SULAMI ET AL., 2024). For BCT, Social Influence - the pressure from network partners or competitors - is a profound driver, reflecting the network-dependent nature of the technology (CHEN ET AL., 2023; CRICELLI ET AL., 2025). Conversely, the lack of Facilitating Conditions, such as adequate IT infrastructure and technical support, severely hinders adoption, particularly in emerging economies (AL-SULAMI ET AL., 2024). Additionally, the Technology Readiness Index (TRI) highlights that personality traits like optimism and innovativeness act as drivers, while technological insecurity serves as a strong deterrent (PARASURAMAN, 2000; ULLAH ET AL., 2021).

### Institutional Theory, TOE Framework, and SME Innovation Dynamics

The adoption of complex networked technologies in SMEs is best contextualized by integrating the Technology-Organization-Environment (TOE) framework (TORNATZKY & FLEISCHER, 1990) with Institutional Theory (DIMAGGIO & POWELL, 1983). The TOE framework underscores that technological complexity, top management support, and environmental pressures collectively dictate adoption readiness (OLIVEIRA ET AL., 2014). However, SMEs often lack the strategic resources, such as specialized human capital and capital reserves, required to proactively exploit BCT as a strategic asset (BHARDWAJ ET AL., 2021). Consequently, SME innovation behavior is predominantly reactive and driven by institutional isomorphism (DIMAGGIO & POWELL, 1983).

Coercive pressures from dominant multinational partners (e.g., mandates for supply chain tracking) or regulatory bodies (e.g., ESG reporting, Digital Product Passports) often force SMEs to adopt technologies merely to maintain market access and ensure survival (ORJI ET AL., 2020; LUSTENBERGER ET AL., 2021). Mimetic pressures also play a role, as companies copy successful competitors to reduce uncertainty under conditions of technological immaturity. Ultimately, the literature suggests that for SMEs, particularly in developing and CEE regions, blockchain adoption is less about proactive strategic innovation based on internal innovativeness and more about compliance within the prevailing supply chain ecosystem (OLIVEIRA ET AL., 2014).

## MATERIALS AND METHODS

### Research Design and Theoretical Framework

This study employed an exploratory qualitative research design based on semi-structured in-depth interviews with strategic corporate decision-makers in the domestic SME sector. This design was considered appropriate because the aim of the research was not to statistically test technology acceptance models, but to uncover the underlying motivations, cognitive barriers, organizational constraints, and institutional pressures shaping blockchain technology adoption decisions among SMEs. The theoretical framework synthesized established models of technology acceptance and organizational innovation, while maintaining clear conceptual boundaries between individual-level, organizational-level, and environmental-level explanatory dimensions. DAVIS'S (1989) Technology Acceptance Model (TAM) was used to interpret cognitive evaluations related to Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). VENKATESH ET AL.'S (2003) Unified Theory of Acceptance and Use of Technology (UTAUT) informed the analysis of Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions. PARASURAMAN'S (2000) Technology Readiness Index (TRI) was incorporated to capture awareness, innovativeness, insecurity, and technology-related hesitation at the decision-maker level.

At the organizational and environmental levels, Institutional Theory and the Technology-Organization-Environment (TOE) framework were applied to examine external adoption pressures and contextual constraints. DIMAGGIO AND POWELL'S (1983) Institutional Theory was used to interpret coercive, mimetic, and normative pressures, particularly those originating from dominant supply chain partners, regulatory requirements, and industry-level expectations. The TOE framework, originally developed by TORNATZKY AND FLEISCHER (1990) and later applied in technology adoption research by OLIVEIRA ET AL. (2014), provided a complementary lens for examining technological, organizational, and environmental conditions influencing blockchain adoption readiness.

The semi-structured interview guide was developed deductively from the conceptual dimensions of TAM, UTAUT, TRI, TOE, and Institutional Theory. These frameworks were not used as validated quantitative measurement scales; rather, they served as theory-informed analytical lenses for structuring the interview protocol and guiding the subsequent deductive cod-

ing process. Accordingly, the study does not claim to validate or statistically test TAM, UTAUT, TRI, TOE, or Institutional Theory. Instead, these models were used to organize the qualitative inquiry and to support the interpretation of recurring patterns in the interview data. To enhance comparability across interviews, selected anchor statements were included at the end of the interview protocol and rated by participants on a 1–7 scale. These ratings were used only as qualitative elicitation devices and descriptive indicators to stimulate deeper narrative responses and to support cross-case comparison. They were not treated as psychometrically validated constructs, nor were they used as a basis for statistical inference.

The complete semi-structured interview guide is presented in Appendix 1.

### Sampling Procedure and Participant Profile

Data collection employed a purposive, stratified sampling method to ensure contextual depth and industry-specific validity. The inclusion criteria strictly required interviewees to hold strategic decision-making or senior operational leadership positions within domestic SMEs, possessing direct oversight of technological investments, IT infrastructure, or organizational innovation processes. In total, 22 semi-structured in-depth interviews (N=22) were conducted. The sample deliberately diversified across five key industries critical to the Hungarian economy: Information Technology (IT) and Software Development, Retail and Logistics, Manufacturing, Agriculture, and Financial Technology (FinTech). Geographically, the participants represented five distinct Hungarian regions (Pest, Hajdú-Bihar, Csongrád-Csanád, Szabolcs-Szatmár-Bereg, and Baranya counties) to prevent localized bias. The composition of the qualitative sample is detailed in Table 1.

### Data Collection Instrument and The "Negative Proof" Method

The primary data collection instrument was designed semi-structured interview guide built around the conceptual dimensions of the TAM, TOE, and UTAUT models. A unique methodological feature of the interviews was the integration of structured anchor questions. These anchors required participants to qualitatively self-assess the intensity of their subjective attitudes on a 7-point scale (1 = completely uncharacteristic, 7 = completely characteristic). This scale was not utilized as a validated quantitative measurement instrument, but rather as a heuristic tool to provoke deeper narrative qualitative responses and structure the interview process. To rigorously test Hypothesis 1 (H1), which posits that the primary barrier is the lack of technological awareness and perceived usefulness rather than pure financial constraints, a specific thought experiment, termed the "negative proof" method, was applied based on the "free paradox" models (LIN ET AL., 2007). This scenario asked decision-makers if they would adopt blockchain technology immediately if a grant provided 100% funding for the software, hardware, and expert integration. This methodological tool effectively isolated hidden operational fears, cognitive resistance, and regulatory (e.g., GDPR) barriers from the explicit investment costs. However, it is important to acknowledge the methodological limitations of this approach. The 'negative proof' is a hypo-

thetical thought experiment designed primarily as an elicitation technique. While it successfully uncovers hidden organization-

al fears, self-reported hypothetical behavior may differ from actual strategic business decisions.

**Table 1. Composition of the qualitative interview sample**

Interview Code	Industry / Activity	County	Respondent's Position	Company Size (Employees)
INT-01	IT - Software Development	Pest	Managing Director	35
INT-02	Agriculture - Arable Farming	Hajdú-Bihar	Head of Family Farm	12
INT-03	Manufacturing - Metal Structures	Szabolcs-Szatmár-Bereg	Production Director	45
INT-04	Retail - Food	Csongrád-Csanád	Managing Owner	28
INT-05	IT - Cybersecurity	Baranya	Technical Manager	18
INT-06	Fintech & Consulting	Pest	Head of Development	42
INT-07	Retail - Building Materials	Szabolcs-Szatmár-Bereg	Logistics Manager	22
INT-08	Manufacturing - Plastic Injection Molding	Pest	Production Administrator	55
INT-09	IT - Software Testing	Baranya	Engineer	25
INT-10	Agriculture - Crop Production	Hajdú-Bihar	Shift Supervisor / Chief Mechanic	32
INT-11	IT - Database Administration	Csongrád-Csanád	Systems Engineer	26
INT-12	Agriculture - Fruits	Szabolcs-Szatmár-Bereg	Farm Manager	8
INT-13	Retail - E-commerce Logistics	Pest	Logistics Team Leader	38
INT-14	Manufacturing - Furniture	Csongrád-Csanád	Plant Manager	24
INT-15	Retail - Building Engineering	Hajdú-Bihar	Senior Warehouseman	15
INT-16	IT - Web Development	Szabolcs-Szatmár-Bereg	Lead Developer	5
INT-17	Manufacturing - Plastic Recycling	Hajdú-Bihar	Engineer	48
INT-18	IT - Compliance / Data Protection	Baranya	Legal Advisor	12
INT-19	Retail - Machine Parts	Csongrád-Csanád	Warehouse Manager	18
INT-20	IT - Network Monitoring	Pest	Junior Analyst	22
INT-21	Manufacturing - Textile	Baranya	Shift Supervisor	52
INT-22	IT - Business Intelligence	Hajdú-Bihar	Analyst	14

Source: Own elaboration based on qualitative data collection.

### Data Analysis Strategy and Limitations

The recorded and transcribed interviews were analyzed using qualitative content analysis (Mayring, 2014). A deductive category formation approach was utilized to evaluate the hypotheses regarding cognitive barriers and external institutional pressures. The coding process incorporated qualitative frequency analysis, which aggregated the occurrences of specific cognitive (e.g., lack of ROI, complexity) and operational barriers (e.g., GDPR fears) within the text corpus to enhance the robustness and transparency of the findings. Patterns of adoption barriers and motivators were also examined across different industry cross-sections to identify sector-specific nuances. While this research design is highly suitable for uncovering deep structural

and cognitive barriers, the study has certain limitations. The exploratory qualitative approach and the sample size (N=22) imply that the statistical frequencies are not representative of the entire domestic SME sector; the objective was contextual depth rather than statistical generalization. Furthermore, to minimize the risk of social desirability bias regarding technological innovation, the anchor questions and the negative proof method were employed, though such bias cannot be entirely eliminated. Lastly, given the rapid evolution of BCT and dynamic regulatory environments (e.g., MiCA regulations), the findings reflect the cognitive and institutional state at a specific cross-sectional point in time.

## RESULT AND DISCUSSION

### The Primacy of Cognitive Barriers over Financial Constraints

The prevailing discourse in technology adoption often posits that the primary obstacle for Small and Medium-Sized Enterprises is the lack of financial capital and the high costs associated with initial investments (BHARDWAJ ET AL., 2021; ORJI ET AL., 2020). However, the qualitative findings of this study fundamentally challenge this assumption. The evaluation of Hypothesis 1 reveals that the foremost barrier to blockchain adoption within the domestic SME sector is a profound cognitive gap: the absence of technological awareness and an exceptionally low level of Perceived Usefulness. Based on the TAM framework, PU is the strongest predictor of adoption. When asked to evaluate the anchor question ("The lack of understanding and concrete business usefulness of BCT is a greater barrier than the cost of implementation" on a 1-7 scale), 17 out of the 22 SME leaders gave the maximum score of 7, with an additional 5 respondents scoring it a 6. The qualitative narratives confirmed that SME decision-makers operate on a strictly pragmatic, short-term cost-benefit logic. This approach is necessitated by the fact that SMEs typically possess limited financial reserves and face intense daily liquidity pressures, compelling them to prioritize investments with immediate, tangible returns over abstract, long-term ecosystem benefits. The abstract concept of "algorithmic trust" or "ecosystem transparency" cannot be readily converted into immediate profit. As a leader in the agricultural sector stated, "My boss always asks: How many liters of diesel do we save with this? With blockchain, there is no answer to that." Similarly, an IT executive noted that traditional SQL databases are faster, cheaper, and universally understood, making the cognitive and financial overhead of blockchain unjustifiable without explicit client demand (MALIK ET AL., 2021).

### The "Negative Proof" Thought Experiment

To rigorously isolate cognitive barriers from financial constraints, the "negative proof" thought experiment, rooted in

the "free paradox" models (LIN ET AL., 2007) was applied. Respondents were asked whether they would adopt BCT immediately if a grant covered 100% of the software, hardware, and expert integration costs. Strikingly, 21 out of 22 corporate leaders explicitly rejected the hypothetical offer or expressed severe hesitation; only one manufacturing executive proactively accepted it.

The justifications for rejecting a "free" technological upgrade revealed four critical hidden barriers:

1. Hidden Operational and Maintenance Costs: SMEs fear vendor lock-in and the ongoing "overhead" of maintaining complex networks. A web developer emphasized: "Who will pay the utility costs of the technology? I don't want the complication even for free if there is no customer demand."

2. Time as Lost Production: In physical sectors (agriculture, manufacturing, logistics), the steep learning curve equates to lost labor hours.

3. The Network Effect Dilemma: Participants recognized the cooperative nature of BCT; adopting a distributed ledger in isolation is rationally meaningless. "What if my partners don't want to use it? Such a system is only worth something if everyone is in it."

4. Legal and Privacy Risks (GDPR): The immutability of the ledger directly conflicts with the GDPR's "right to be forgotten". IT and compliance experts stated they would not deploy BCT in a live environment while this legal contradiction persists.

### Perceived Ease of Use (PEOU) and Sectoral Cognitive Dissonance

While Perceived Ease of Use (PEOU) is a significant barrier, the qualitative data highlighted sharp sectoral disparities. In the IT sector, BCT does not cause cognitive dissonance (average PEOU barrier score: 4.25); developers often view it as a professional challenge. However, in traditional sectors like agriculture and manufacturing, abstract concepts like "hashes" and "smart contracts" generate severe resistance (average score > 6.00).

Table 2. Summary of anchor questions evaluating cognitive and operational barriers (mean values on a 1–7 scale)

Industry Segment	Lack of Perceived Usefulness (PU) vs. Cost Barrier	Perceived Ease of Use (PEOU) Barrier
IT Sector (N=8)	6.37	4.25
Agriculture (N=4)	7.00	6.50
Retail / Logistics (N=5)	6.40	5.80
Manufacturing (N=4)	6.75	6.00
FinTech (N=1)	6.00	3.00
Overall Average	<b>6.50 (High barrier)</b>	<b>5.11 (Medium barrier)</b>

Note: These numerical summaries are used only as descriptive sensitizing indicators and are not intended for statistical inference. 1 = Completely disagree, 7 = Completely agree.

Source: Own elaboration.

To triangulate these findings, a qualitative frequency analysis was conducted on the occurrence of specific cognitive and operational barriers within the interview corpus (MAYRING, 2014). The lack of visible ROI was reported by 21 out of 22

respondents, making it the most ubiquitous barrier, overshadowing the high cost of implementation (mentioned by 15 out of 22).

**Table 3. Frequency analysis of primary adoption barriers (N=22)**

Coded Adoption Barrier	Frequency of Mentions	Explanation in the Context of H1
1. Lack of visible business benefit / ROI	21 / 22	Almost all respondents (except FinTech) reported the lack of immediate, monetary return as the primary barrier. This confirms that Perceived Usefulness (PU) is the most critical factor.
2. Complexity / Lack of adequate IT knowledge	16 / 22	Particularly strong cognitive barrier in manufacturing, retail, and agriculture sectors.
3. High implementation / operational cost	15 / 22	Cost is a significant barrier, but often secondary to the lack of benefit. Respondents indicated that clear benefits would justify costs.
4. Data security / GDPR and trade secret fears	14 / 22	SMEs fear transparency, competitive exposure, and regulatory conflicts (e.g., GDPR compliance).

Note: *Qualitative frequency analysis based on deductive coding.*

Source: *Own elaboration.*

### Institutional Pressures vs. Internal Innovation

Hypothesis 2 posited that SME adoption intention is driven predominantly by external environmental pressures rather than internal organizational innovativeness. The findings strongly corroborate Institutional Theory (DIMAGGIO & POWELL, 1983) and the environmental dimension of the TOE framework (TORNATZKY & FLEISCHER, 1990; OLIVEIRA ET AL., 2014).

### Coercive Isomorphism as the Primary Catalyst

The most consistent result across the interviews was the acceptance of external coercion as the sole viable trigger for adoption. Coercive institutional isomorphism, which refers to the process where organizations are compelled to adopt similar structures or technologies due to external pressures from more powerful entities and regulatory frameworks (DIMAGGIO & POWELL, 1983). When evaluating the anchor question ("We would not adopt it ourselves unless forced"), 15 respondents gave the maximum score of 7. SMEs generally occupy subordinate positions in global value chains, resulting in fundamentally reactive technological strategies.

Two main forms of coercive pressure were identified:

1. **Multinational Partner Mandates:** If top-tier companies (e.g., automotive giants, global retail chains) mandate block-chain-based tracking, SMEs will immediately integrate it to survive. A manufacturing director bluntly stated: "90% of SMEs work like this: if the big fish says we have to dance like this, we dance like this, otherwise we fall out of the basket."

2. **Regulatory Compliance:** The second strongest driver is government and EU mandates, such as the implementation of the Digital Product Passport (DPP) or ESG reporting. Respondents likened this to the mandatory introduction of online tax invoicing: "Nobody wanted it, but everybody did it because they had to."

### Mimetic Pressures and the Absence of Internal Proactivity

Internal innovation affinity (strategic proactivity) is critically low in traditional SME sectors, limited mostly to modernizing physical machinery rather than software infrastructure. Consequently, mimetic isomorphism (copying competitors to reduce uncertainty) only exists in a latent form. SMEs reported a medium level of competitive pressure (average score: 4.45); they would only emulate competitors if BCT had already proven to secure a definitive market advantage.

**Table 4. Evaluation of Institutional Theory and TOE factors driving adoption intention (mean values on a 1–7 scale)**

Industry Segment	Coercive Pressure (Institutional)	Competitive Pressure (TOE)	Internal Innovation Affinity (TOE)
IT Sector (N=8)	6.12	4.62	5.50
Agriculture (N=4)	7.00	4.50	1.75
Retail / Logistics (N=5)	7.00	4.80	2.20
Manufacturing (N=4)	7.00	4.25	1.25
FinTech (N=1)	5.00	7.00	7.00
Overall Average	6.54 (Very High)	4.68 (Medium)	3.50 (Polarized / Low)

Note: *These numerical summaries are used only as descriptive sensitizing indicators and are not intended for statistical inference. 1 = Completely disagree, 7 = Completely agree.*

Source: *Own elaboration.*

**Table 5. Frequency analysis of decision-making motivations (N=22)**

Decision-Making Motivation	Frequency of Mentions	Explanation in the Context of H2
1. External Coercion: Mandates of multinational partners / clients	19 / 22	The most frequent catalyst for future adoption. Supports coercive isomorphism.
2. External Coercion: Legal / Regulatory requirements (e.g., EU, Tax Authorities)	17 / 22	Regulatory pressure is the second strongest driver of adoption.
3. Competitive Pressure (Mimetic isomorphism)	10 / 22	Firms follow competitors only after proven market advantage.
4. Internal Innovation Affinity (Strategic proactivity)	3 / 22	Only FinTech and a few IT firms indicated proactive adoption without external pressure.

Note: Qualitative frequency analysis based on deductive coding.

Source: Own elaboration.

**Evaluating Adoption through the UTAUT Framework**

Synthesizing the qualitative data through the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003) provides a structured understanding of the SME context:

- Performance Expectancy (PE): Critically low. Most respondents do not perceive BCT as outperforming traditional cloud ERPs or SQL databases in terms of daily operational speed. A logistics supervisor feared that waiting for "block confirmations" would slow down warehouse picking.

- Effort Expectancy (EE): Exceptionally high. In physical production sectors, the expected effort to train an aging or non-digitally native workforce (e.g., textile workers, farm laborers) to interact with decentralized interfaces is viewed as an insurmountable barrier.

- Social Influence (SI): This dimension perfectly overlaps with coercive institutional pressure. SI is exerted exclusively top-down by multinational clients or regulatory bodies. Horizontal SI from IT consultants or chambers of commerce is met with skepticism, often viewed as vendor-driven upselling.

- Facilitating Conditions (FC): The SME sector suffers from a lack of FC. Many traditional companies lack dedicated in-house IT personnel, relying on outsourced, ad-hoc system administrators. Furthermore, basic infrastructure is often missing. As one agricultural leader noted, "First, let's have proper cell reception on all our lands, and then we can talk about blockchain."

**Sectoral Nuances and the "Transparency Paradox"**

The analysis revealed a profound "transparency paradox" within the agricultural and manufacturing sectors. While BCT's core value proposition is data integrity and traceability, SMEs view this transparency as a strategic threat rather than an asset. Farmers and manufacturers fear that opening the supply chain ledger will expose highly guarded trade secrets, such as yields, procurement costs, and proprietary formulas to competitors or tax authorities. In the Hungarian SME culture, business is still heavily reliant on informal, trust-based relationships, making the algorithmic exposure of data a severe deterrent. This creates a paradoxical situation where the very feature that makes blockchain valuable at the ecosystem level (total transparency) becomes its greatest cognitive barrier at the micro-organizational level, as SMEs perceive information asymmetry as a protective mechanism for their market position. Conversely, in the FinTech sector, internal business processes directly benefit from

BCT (e.g., cross-border payments, KYC logging). For these entities, the barrier is not a lack of PU, but rather navigating the nascent and overly strict regulatory environments (e.g., MiCA regulations).

**CONCLUSION**

In summary, the empirical evidence supports both research hypotheses. Hypothesis 1 (H1) is supported, as the negative proof thought experiment and the structured anchor questions indicated that the fundamental cognitive gap, specifically the severe lack of perceived business usefulness and technological awareness, acts as a far more formidable barrier to SME adoption than pure financial constraints. Furthermore, Hypothesis 2 (H2) is supported by the qualitative data, which revealed a structural absence of internal organizational innovativeness regarding decentralized networks. The adoption intentions of SMEs are almost exclusively reactive and dictated by coercive institutional isomorphism, primarily originating from the mandates of dominant supply chain integrators and strict regulatory compliance requirements. While this study offers deep contextual insights, its limitations lie in its exploratory qualitative design and specific geographical focus on Hungary. The sample size precludes broad statistical generalization. Future research should employ longitudinal quantitative designs to track how SME cognitive attitudes and institutional pressures evolve.

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## APPENDICIES

### Appendix 1. Semi-Structured Interview

#### INTRODUCTION

"Please introduce your company in a few sentences, what industry do you operate in, what is the size of the company, and what is your exact role in making decisions about technological investments?" (TRI - Awareness / Baseline measurement): "If you had to briefly explain to a lay industry partner what blockchain technology is in your understanding, specifically beyond cryptocurrencies, with a business focus, how would you phrase it?"

#### BLOCK I:

Awareness vs. Complexity and Costs (TAM - Perceived Usefulness / H1): "Based on your current knowledge, do you see any specific, everyday processes or business problems in your own company that blockchain technology could solve more efficiently? If so, what would they be?"

(TAM - Perceived Usefulness / H1): "Do you currently see enough added value in blockchain that would make it worthwhile to replace or supplement your well-established, existing IT systems and processes?"

(TRI - Insecurity & Awareness / H1): "When you hear about a relatively new, widely discussed technology like this, what risks or uncertainties do you see in it? Is there perhaps distrust from management because the operation of the technology is difficult to understand?"

(TAM - Perceived Ease of Use & UTAUT - Effort Expectancy / H1): "How complicated do you think it would be for your own employees and your IT team to understand, learn, and use blockchain-based systems on a daily basis?"

(UTAUT - Price Value / H1): "When judging such a technology, how much weight does the implementation cost carry? Is it the absolute amount of the investment that is alarming for SMEs, or rather that the return on investment (ROI) is unpredictable?"

(Synthesis of TAM, UTAUT, TRI / H1 - The "Negative Proof"): "Let's do a thought experiment! Suppose that tomorrow you win a non-refundable grant that covers 100% of the system, and a professional team of experts performs the entire technical integration for free. So, there is no cost and no technical burden. In this case, would you immediately adopt the technology, or is there something else, for example, the lack of real business benefit, that would still make you hesitate?"

#### BLOCK II:

External Pressure vs. Internal Innovation Willingness (TRI - Innovativeness / H2): "Generally speaking, where would you place your company on the technology adoption curve? Do you like to be first and experiment, or do you prefer to wait until the big players pay the learning costs, and only adopt proven

technologies?"

(TOE - Organization & Context / H2): "Has there ever been an instance in your company's life where you implemented a completely new, unproven digital technology entirely out of internal determination, simply to gain a strategic advantage?"

(Institutional Theory - Mimetic pressure & TOE - Competitive Environment / H2): "How closely do you monitor the technological steps of your direct competitors? Would you embark on a blockchain project simply because you see your competitors doing it and fear falling behind?"

(Institutional Theory - Coercive pressure & UTAUT - Social Influence / H2): "How would your company react if your most important client, for example, a multinational partner, or your dominant supplier network suddenly made the use of a blockchain-based tracking system mandatory starting tomorrow?"

(Institutional Theory - Normative pressure / H2): "How much influence do industry standards, recommendations from professional chambers, or the opinions of external IT consultants have on your decisions when implementing new technology?"

(TOE vs. Institutional Theory / H2): "Overall, looking at the spread of blockchain in the domestic SME sector: What do you think will bring the breakthrough? An internal maturation process where company leaders recognize the usefulness of the technology, or rather an external 'coercion' where the supply chain dictates the conditions, or perhaps a better financial support environment?"

#### *CLOSING BLOCK:*

"At the end of our conversation, I will read five short statements. Please tell me to what extent you agree with them on a scale of 1 to 7 (1: totally disagree, 7: completely agree)."

1. (TAM - PU vs. Cost / H1): "The lack of understanding and concrete business usefulness of blockchain technology is currently a greater barrier for us than the financial cost of implementation." [ \_\_\_ ]

2. (TAM - PEOU / H1): "The excessive complexity of the technology is the main reason SMEs shy away from blockchain." [ \_\_\_ ]

3. (Institutional Theory - Coercive / H2): "In our industry, SMEs will not use blockchain on their own, only if large partners or regulations force them to." [ \_\_\_ ]

4. (TOE - Competitive / H2): "We would only move towards blockchain if the competition is already proven to be successfully using it, putting us at a competitive disadvantage." [ \_\_\_ ]

5. (TRI - Innovativeness / H2): "Our company proactively and independently seeks out such pioneering solutions, regardless of external pressures." [ \_\_\_ ] "

Do you have any other comments or observations?"

# INFORMATION AND COMMUNICATION TECHNOLOGIES' USE EXPERTISE AND THE UTILISATION BY FRUIT VEGETABLE FARMERS IN NIGERIA

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**Abstract:** *Information and Communication Technologies (ICTs) are valuable tools for developing farmers' capabilities to optimise production resources. The study assessed fruit and vegetable farmers' expertise and utilisation of ICT for cucumber and watermelon production. Members of the Osun State Exotic Fruit Farmers' Group were randomly sampled (90 of 102 farmers) for the study. Data were collected using an interview schedule and analysed using descriptive statistics and multivariate regression analysis. Results reveal the farmers' mean age was 43.8±10.33 years, and two-thirds (66.67%) were male. Low proportions (19.2% and 14.81%) were good and excellent in ICT use expertise, while many (42.96%) were poor. Some (18.89%) explored social media to link high-value markets, and 16.67% searched online pages or links to learn about artificial pollination. Farmers' ICT use expertise and extent of utilisation for cucumber and watermelon production were significantly influenced by their familiarity with ICT tools ( $b = 1.29$  and  $1.47$ ) and years of ICT use experience ( $b = 0.09$  and  $0.16$ ), respectively, at  $p \leq 0.05$  significance level. Experience and familiarity with ICT usage spurred farmers to greater proficiency and consequent increased utilisation to optimise cucumber and watermelon production. Specialised ICT training should be prioritised for farmers' capacity building in intervention programmes.*

**Keywords:** *ICT proficiency, Optimal production, Social media, Vegetable production*  
(JEL code: O33)

## INTRODUCTION

Information and Communication Technology (ICT) has brought about changes that have tremendously facilitated science, education, trade, and diverse interactions in human endeavours. The diversity of relevance and applications espoused a variety of definitions across disciplines and people. More commonly, ICT tends to be described as modern technological tools for collecting, aggregating, processing, storing, retrieving, and transmitting information such as numeric or textual data, voice or sound, images, and related media (Al-Rahmi et al., 2020). This description revolves around the devices and infrastructures that facilitate the production, processing, transfer, and use of information through digital means such as radio, television, computers, projectors, digital cameras, mobile phones, and internet media. The foremost of these, radio, remains an effective mass communication tool that is accessible and context-defined appropriate technology for agricultural information delivery to the rural fringes in many countries of sub-Saharan Africa (Balogun et al., 2020; Olanrewaju and Farinde, 2017). The experiences

provided by such pioneer ICTs opened the door for the fast infiltration of society with the later generation of ICT devices, such as computers, mobile phones, and internet media, among others.

The use of contemporary ICT has now proven its wide potential and coverage improvement among grassroots farmers (Adeyemi et al., 2023; Balogun et al., 2021). This improvement stems from its role in facilitating the primordial importance of agricultural information use as an input for production. The use of ICT is providing alternative media that facilitate necessary interactions and relationship building for researching and communicating good agricultural practices and innovations to farmers. Al-Rahmi et al. (2020) buttressed that ICT offers self-paced learning opportunities to farmers through online resources, platforms for knowledge sharing, and mobile applications offering support services relevant to farming activities. More so, the importance is unmatched in evolving and nurturing linkages for securing connections to high-level markets for farm produce as well as cost-effective input sourcing. Furthermore, financial services access is now chiefly mediated by ICT, as many

banking services, including credit procurement, are accessed through online applications and websites. This portends a medium for the financial inclusion of farmers in remote locations and their integration into the larger society, thereby benefiting from the dividends of technological, economic, and social services and product development through ICT utilisation. This is highly valuable in many African countries, such as Ethiopia and Nigeria, where the intentional uptake of ICT in farming started relatively late compared with the other sectors of their economy (Getahun, 2020; Sennuga et al., 2022; Ayim et al., 2022). As such, the trending agricultural digitalisation, as a strategic pathway for improving productivity and resilience, is poised to change the narratives of traditional farming through improved information transfer, marketing and financial exchanges, climate-smart innovations adoption, and technological inclusion, as well as access to extension and other supports (Food and Agriculture Organisation, 2022).

In recognition, studies abound on awareness and use of ICT in relation to agriculture in Nigeria (Hasan et al., 2019; Chiazoka et al., 2021; Adeyemi et al., 2023). It is established that most farmers are more familiar with traditional ICTs such as radio and television when compared with contemporary ICTs such as the Internet and cable networks (Fawole and Olajide, 2012; Sennuga et al., 2020). The literature has also shown uneven benefits of agricultural digitalisation with evidence of underlying factors of variations in infrastructure, digital literacy, socioeconomic characteristics, and institutional support systems, among others (Arangurí et al., 2025; Makinde et al., 2025; Choruma et al., 2024). However, farmers' engagement with ICT is not chiefly a function of access and availability but also of technology acceptance and use capability or behaviour. This underpins the persistence of gaps in the meaningful use of ICT amidst improving digital technologies coverage, particularly among smallholder farmers, women, and rural populations (Abdulai et al., 2023; Ngulube, 2025). Accordingly, emphasis on digital tools coverage in line with the views of the Diffusion of Innovation theory by Rogers as mechanistic for ICT adoption has given way to a shift in scholarly attention from simple measures of ICT ownership, access, and availability to emphasising digital competence or expertise and the outcomes (Nguyen and Habók, 2023; Sharp, 2023; Vuorikari et al., 2025).

To this end, exploring the framework of Experiential Learning Theory (ELT) by David Kolb (1984) to advance knowledge on farmers' use of ICT is of great value. This directs to the viewpoint of competency or expertise development, alluding to gains of prior experience with ICT. In differentiating ELT from other cognitive learning and behavioural theories, Kolb et al. (2000) assert that subjective experience, such as farmers' initial familiarity with ICTs and experience of purposes to be served, shapes usability knowledge or skill and its use. Hence, experience could be projected as a factor in the ICT use expertise of farmers and the eventual depth of use in facilitating production activities. While this framework offers a different pathway for understanding the discourse of ICT utilisation in production activities, many studies in the literature have dwelled on issues of perceived usefulness or attitudes towards use, which are closer to that hypothesised in the Technology Acceptance Model (TAM). The TAM application to ICT use identifies intrinsic

factors of perceptions about benefits and use, and these have become widely researched in studies including Yekini et al. (2019), Eweoya et al. (2021), Adesiji et al. (2024) and Kehinde and Ayanwale (2026), among others. These have produced a gamut of benefits of ICT in agriculture, especially in the timely delivery of information, increased interactions among farmers, and communication between farmers and agricultural extension workers (Obeng et al., 2019; Salam and Khan, 2020; Mishra et al., 2020). In contrast, experiential precursors to ICT use expertise as well as the outcome of utilisation remain underexplored in the literature, particularly within the developing contexts of Africa.

The consideration of this ELT approach among organised watermelon and cucumber producers in Nigeria offers a unique discussion on the ICT use expertise of farmers, as well as the effects on pragmatic utilisation in production activities. This portends addressing the limitation in the literature for explaining variations in ICT utilisation among farmers based on differences in their levels of experience and technological competence. Hence, the study addressed the following objectives:

- i. Assess the level of expertise of the farmers in ICT usage;
- ii. Examine the utilisation of ICT for watermelon and cucumber production activities.
- iii. Examine the effects of farmers' experience on ICT use, expertise and utilisation for watermelon and cucumber production

### Hypothesis

The study hypothesis is stated in the null form on the link between ICT use expertise and the utilisation in production activities as follows:

There is no significant relationship between farmers' ICT use expertise and the utilisation in watermelon and cucumber production activities.

## MATERIALS AND METHODS

The study area is Osun State in southwestern Nigeria. It is an inland state comprising tropical rainforest and derived savannah zones. The derived savannah zones, which favour watermelon and cucumber production, unlike the forest region, have witnessed the successful commercialisation of watermelon and cucumber production. Also, there is increasing awareness of the economic potential of the two crops available through substantial market demand. This has motivated clustered as well as fragmented production plots in the zones. Unlike common crops in the area, farmers interested in cucumber and watermelon production are obliged to learn about cultivation and management processes, in which ICT use holds immense potential. For this value, the study population is composed of commercial cucumber and watermelon farmers. Currently, many of these farmers are organised in a group registered with the government and named the Exotic Fruit Vegetable Growers Association. This group has a membership strength of 102 members. Using a simple random sampling technique, 90 farmers were sampled as a representative group of the association.

The instrument employed for the study is a structured ques-

tionnaire developed to elicit valid information on the farmers' level of expertise in using ICT and the array of uses for which ICT was employed in their production endeavours, among others. Through the identification of relevant ICT in literature and reconnaissance survey affirmation of accessibility to the farmers, the ICTs focused on are social media platforms, e-mail, web-documents and repositories, among others. The research instrument was validated for face and content validity by the Agricultural Extension and Rural Development specialists of the College of Agriculture of Osun State University, Osogbo. Their suggestions and comments were collated and used to revise the instrument to obtain a clearly focused questionnaire for the field exercise. This was administered to the sampled farmers by trained enumerators through face-to-face contact at the end of the monthly meetings of the farmers' association for the months of March and April, 2023. The 2 sessions generated a total of 90 sufficiently filled questionnaires for analysis.

The study variables comprise the socio-economic characteristics of the respondents, including production experience and ICT exposure; ICT use expertise and utilisation of ICT in watermelon and cucumber production activities. Basically, ICT use expertise was operationalised by listing a total of 9 common ICTs relevant to purposeful use in the watermelon and cucumber production context of the study area. Also, the 5-point rating scale used by Olatoye et al. (2021) for ICT proficiency skills assessment was adopted for scoring farmers' expertise level for each of the listed ICTs. This includes 5 expertise levels, viz., poor, fair, good, very good, and excellent, which were scored 1 to 5 sequentially. The respondents' scores per item were aggregated as a continuous variable for the ICT expertise.

Utilisation of ICT was also tested based on the 9 uses identified in the reconnaissance survey of relevant ICT uses in watermelon and cucumber production. A 4-point Likert scale, comprising never, rarely, sometimes, and always, was used to assess the depth of use for each of the 9 items. These were scored 0, 1, 2 and 3, respectively. The weighted mean score was computed for the description of the results per item, while the aggregate score of the items was obtained as the continuous score employed for inferential analysis.

Data elicited on the socio-economic characteristics were analysed using descriptive statistics. This comprises the use of frequency counts and percentages for categorised variables like sex, marital status, sources of farm credits and the ordinal scales of ICT use and expertise assessment. Means and standard deviations were also computed for interval variables like age and household size. The effect of experience-related variables on ICT use expertise and utilisation in production activities was assessed using multivariate regression analysis. This involved testing the actual values collated for the respondents on the number of familiar ICT, years of use of ICT, farming experience in years and average annual income as causal variables of farmers' ICT use expertise and utilisation of ICT in production activities. This was prompted to determine the effect of these indicated precursors, initially tested to be significantly correlated, on the composite scores of ICT use expertise and utilisation in production activities. Finally, ordinary linear regression was used to test the eventual influence of ICT use expertise on the utilisation in cucumber and watermelon production activities.

The explicit forms of the functions to be expressed are given as:

$$Y_{i,j} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + e$$

Where,

Y = Dependent variable

Y<sub>1</sub> = ICT use expertise

Y<sub>2</sub> = ICT utilisation in watermelon and cucumber production

X<sub>1</sub> = Number of familiar ICT

X<sub>2</sub> = Years of ICT use (persons)

X<sub>3</sub> = Years of farming experience

X<sub>4</sub> = Average annual income (₦)

e = Random error term

β<sub>0</sub>, β<sub>1</sub> - β<sub>7</sub> = Regression coefficients

## RESULTS AND DISCUSSION

### Socio-economic characteristics

Results in Table 1 show that one-third of the fruit and vegetable farmers were aged between 40 and 50 years, while 35.56% were below 40 years in age. Many (67%) were males, while one-third were females, and they were mostly (80%) married individuals. These show a good representation of youth farmers, who were predominantly males with marital obligations, dominating the fruit and vegetable production in the area. The indication that male fruit and vegetable farmers constitute twice the number of females reveals a shift in the cultural dominance of women in vegetable production. As such, regarding vegetables as women's crops, this trend may no longer be valid if it continues. Also, the majority (70%) of the farmers had households with 5 to 8 people in them, and the mean household size of the farmers indicated an average of about 6 people per household. A substantial proportion (48%) of these farmers had less than 10 years of experience in fruit and vegetable production. This would be due to the evidence of the high number of young people among the farmers. These results support the findings of Jimoh et al. (2016) on cucumber farmers in the study area, who were around 41 years of age with less than 10 years of production experience and were predominantly males. More so, two-thirds (66.67% and 68.89%) indicated that they had participated in some form of ICT training and had access to farm credits, respectively. As such, many of the farmers were familiar with ICT, and this might predispose them to employ the ICT tools during their watermelon and cucumber production activities.

**Table 1. Socio-economic characteristics of the farmers**

<b>Socio-economic</b>	<b>Frequency</b>	<b>Percentage</b>	<b>Mean±sd</b>
<b>Age (years)</b>			43.8±10.33
Below 40	32	35.56	
40-50	30	33.33	
Above 50	28	31.11	
<b>Gender</b>			
Male	60	66.67	
Female	30	33.33	
<b>Household sizes</b>			5.4±1.4
0-4	24	26.67	
5-8	63	70	
9 and above	3	3.33	
<b>Marital status</b>			
Single	8	8.89	
Married	72	80	
Divorced	1	1.11	
Separated	4	4.44	
Widowed	5	5.56	
<b>Farming experience (years)</b>			16.5±4.8
0-10	43	47.78	
11-20	21	23.33	
Above 20	26	28.89	
<b>Participated in ICT training</b>	60	66.67	
<b>Participation in CBO</b>	72	80	
<b>Accessed farm credits</b>	62	68.89	
<b>Farm credits sources</b>			
Personal savings	33	36.67	
Family/friends	7	7.78	
Microfinance bank	2	2.22	
Commercial bank	36	40	
Local group cooperative	8	8.89	
Religious bodies	3	3.33	
<b>Accessing agricultural extension services</b>	29	32.2	

Source: Field survey, 2023

### ICT Use Expertise

Results in Table 2 show that about one quarter of the farmers were proficient, excellent and good, respectively, in the use of social media messaging. While less than one-fifth (16.7%) were adjudged excellent in online video and audio lecture use, 23.3% and 24.4% had average and good levels of expertise in media usage. Close to half (47.8% and 45.6%) had poor expertise in the use of electronic library resources and use of search engines for accessing sites and links, respectively, while only 15.6% and 10%, respectively, were excellently proficient in the use of these ICT facilities. Similarly, about one-quarter (27.8%) were found to be good at accessing and using web-based documents. The majority (60% and 51.1%) of the farmers were poor users of online archives and repositories of international agricultural organisations, while only about one in every 10 people (11.1%) were excellent users of these media.

Accordingly, online/social media messaging ranked first as the ICT in which the farmers had the best expertise relative to others listed. Online video and audio lectures ranked second (2nd), electronic mail (e-mail) ranked third (3rd), World Wide Web-based documents ranked fourth (4th), and electronic and online library resources ranked fifth (5th) as the ICT facilities in which farmers had some level of expertise. These reveal that farmers were more proficient in the use of social media messaging, online video and audio lectures, as well as electronic mail (e-mail), while they were least proficient in exploring online

archives and repositories of international agricultural organisations. This emphasises the increasing popularity of social media messaging platforms with a reported increase in use by farmers for agricultural information access and agricultural marketing, among others (Adejo and Opeyemi, 2019; Inegbedion et al., 2020).

Overall, the results generally show that many of the farmers were not proficient in the use of all the listed ICTs, as shown by the fact that between 30% and 60% were indicated to be poor in terms of the use of each of the ICTs. This reveals the prevalence of poor expertise in ICT utilisation among farmers. The implication of this is that many farmers lack the adequate skills required to successfully navigate through a variety of ICT facilities for productive purposes, despite the widespread use of ICT, improved coverage and access to digital tools. This highlights a substantial gap in farmers' skills with contemporary resources that could facilitate the optimisation of watermelon and cucumber production activities.

**Table 2. Distribution of farmers by the expertise of ICT usage**

ICT	Poor	Fair	Average	Good	Excellent	Rank
Online/social media messaging	35.56	2.22	13.33	24.44	24.44	1 <sup>st</sup>
Online video and audio lectures/ Electronic mail (e-mail)	31.11	4.44	23.33	24.44	16.67	2 <sup>nd</sup>
World Wide Web-based documents	37.78	10	5.33	33.33	15.56	3 <sup>rd</sup>
Electronic/online library resources	35.56	7.78	15.56	27.78	12.22	4 <sup>th</sup>
Digital electronic media	47.78	7.78	3.33	15.56	23.33	5 <sup>th</sup>
Search engines for accessing sites and links	42.22	6.67	34.44	17.78	8.89	6 <sup>th</sup>
Online archives	45.56	5.56	24.44	14.44	10	7 <sup>th</sup>
Online repositories of international agricultural organisations	51.11	16.67	12.22	8.89	11.11	8 <sup>th</sup>
<b>Average proportion</b>	60	12.22	6.67	10	11.11	9 <sup>th</sup>
	42.96	8.15	15.41	19.62	14.81	

Source: Field survey, 2023

**Level of utilisation of ICTs for cucumber and watermelon production activities**

The results (Table 3) show that substantial proportions (31.1% and 38.89%) of the farmers frequently (sometimes and always) utilised ICTs for obtaining information on hybrid seeds and their sources. This is indicated as the highest-ranked purpose for which the farmers employ the use of ICTs in their vegetable production prowess. Also, many (42.2%) farmers always use ICT to link up with their co-farmers to share experience on cucumber and watermelon production. Getting the procedure of the artificial pollination process for hybrid watermelon and cucumber varieties was the third ranked, as it indicated that 24.4% and 38.89% of farmers sometimes and always use ICT to this end, respectively. About 7 in every 10 farmers (68.9%) at least utilise ICT for getting information on sequential production steps and learning about production needs. This was the fourth-ranked utility of ICT by the farmers' utilisation in cucumber and watermelon production. About one-third (32.2% each) sometimes and always use ICT for obtaining information on best practices for fertiliser and agrochemicals used in cucumber and watermelon production.

While 32.2% had never used ICT for aiding knowledge of watermelon and cucumber farm management, 34.4% were found to use ICT always for this need, and it ranked the sixth

most basic utilisation of vegetable farmers. Similarly, more than one-third (35.56%) of the farmers always use ICT for securing marketing linkage, just as about a quarter (24.4%) and 27.78% always and sometimes use ICT for getting informed about cucumber and watermelon technologies. Regarding ICT use for signing up to mailing lists of organisations supporting fruit and vegetable farmers, many (42.2%) and 16.67% had never and rarely, respectively, used ICT for this, but some (27.78%) sometimes use ICT to this effect. This was indicated as the least frequent use of ICT by the farmers in the cucumber and watermelon production processes.

Based on the results, it is evident that a substantial number of the farmers were using ICT in varied forms related to cucumber and watermelon production. As such, the findings highlight the prominence of ICT use for obtaining information on hybrid seeds, networking with co-farmers for sharing production experiences, and learning about technical procedures or artificial pollination processes. This makes it clear that ICT gives farmers the opportunity to access technical support for optimised watermelon and cucumber production in Nigeria. This corroborates the recorded variety of benefits of ICT use in agricultural production as exemplified by studies like Yekini et al. (2019), Adesiji et al. (2024) and Kehinde and Ayanwale (2026).

**Table 3. Level of Utilisation of the ICTs in watermelon and cucumber production**

Production purposes	Never	Rarely	Always	WMS	Rank	
Obtaining information on hybrid seeds and their sources	26.67	3.33	31.11	38.89	1.82±1.2	1 <sup>st</sup>
Linking up with co-farmers to share experience on cucumber/watermelon	27.78	13.33	16.67	42.22	1.73±1.3	2 <sup>nd</sup>
Getting the procedure of the artificial pollination process for hybrid varieties	30	6.67	24.44	38.89	1.72±1.3	3 <sup>rd</sup>
Getting information on sequential production steps and needs	27.78	3.33	38.89	30	1.71±1.2	4 <sup>th</sup>
Obtaining information on best practices on fertiliser and agrochemicals use	28.89	6.67	32.22	32.22	1.67±1.2	5 <sup>th</sup>
Aiding knowledge of watermelon and cucumber farm management	32.2	7.78	25.56	34.44	1.62±1.3	6 <sup>th</sup>
Linking potential buyers/uptakers of watermelon/cucumber	27.78	18.89	17.78	35.56	1.61±1.2	7 <sup>th</sup>
Informing on the latest technologies relevant to cucumber/watermelon production	35.56	12.22	27.78	24.44	1.41±1.2	8 <sup>th</sup>
Signing up to the mailing list of organisations supporting fruit vegetable farmers	42.22	16.67	27.78	13.33	1.12±1.1	9 <sup>th</sup>

Source: Field survey, 2023

### Effect of farmers' experience on ICT use expertise and utilisation for production activities

Results in Table 4 show the results of multivariate regression of experience-related factors with ICT use expertise and the utilisation for production activities by the farmers. It was shown that the number of ICTS known ( $b = 1.36$  and  $1.19$ ) and the years of use ( $b=0.15$  and  $0.08$ ) had a positive and significant influence on both ICT use expertise and the utilisation for production activities by the farmers, respectively. Production experience factors, namely years of production and income, were not statistically significant in relation to the expertise and utilisation of ICT by farmers. This signifies the importance of farmers' exposure to ICTs over the depth of farming experience as a predisposing factor for tapping into contemporary oppor-

tunities offered by ICTs for enhancing farmers' production capabilities. The cognitive experience developed from interacting with ICT resources is identified as fostering expertise in usage, as well as the extent of application for facilitating production activities. This means that the more conversant the farmers are with ICTs, the more their expertise and the higher the tendency for utilisation in their production activities. These results showcased ELT assertion of the process of competency development involving concrete experience build up to active experimentation or use. The finding specifies actual ICT use experience over farm production experience as the precursor of farmers expertise development and meaningful utilization of ICT in production activities.

**Table 4. Results of multivariate regression of farmers' experience factors with ICT use expertise and the utilisation in production activities**

	Experience Factors	b	Standard error	t	P value
ICT uses expertise	Number of familiar ICTs	1.36	0.133	10.16	0.000*
	Years of ICT use	0.152	0.0359	4.23	0.000*
	Farming experience	0.097	0.074	1.30	0.198
	Average annual income	-1.36e-06	7.50e-07	-1.81	0.704
	Constant	9.26	1.37	6.76	0.000*
ICT utilisation in production activities	Number of familiar ICTs	1.197	0.124	9.67	0.000*
	Years of ICT use	0.084	0.033	2.54	0.013*
	Production experience	0.085	0.069	1.24	0.22
	Average annual income	-8.30e-07	6.95e-07	-1.19	0.236
	Constant	3.129	1.27	2.47	0.016*

\*Significant at  $P \leq 0.05$ .

ICT expertise:  $F=89.71$ ,  $R^2= 0.808$ ; ICT utilization in production  $F=66.89$ ,  $R^2= 0.759$ .

Source: Own elaboration

### Hypothesis test result

Results in Table 5 show that farmers' expertise in ICT is significantly related to the utilisation of ICTs in cucumber and watermelon production. This reveals that as farmers' expertise in ICT use increases, utilisation of ICT in production activities increases and vice versa. This makes the capacity for effective use of ICT imperative for the potential to employ ICT

for enhancing production activities. This result simulates that of Olanrewju et al. (2024), which indicated that the level of expertise in using ICTs translates into substantial productive use among farmers. Also, the finding reflects the causal potential of expertise improvement on actual utilisation of ICT in line with the position of ELT.

**Table 5. Result of regression analysis showing the relationship between ICT use expertise and utilisation in watermelon and cucumber production**

	b	t	P-value
Expertise	1.37	0.08	15.45
Constant	3.67	0.85	4.31

$F = 238,8$ , Adjusted  $R^2 = 0.727$ ,  $P\text{-value} = 0.000$

Source: Own elaboration

## CONCLUSION

Social media messaging, online video and audio lectures, as well as electronic mail (e-mail) were the major ICTs in which the fruit vegetable farmers had appreciable use expertise. Aside from these, the farmers generally had poor expertise, showing inadequate skills required to successfully navigate through a variety of ICT facilities for productive purposes. Yet farmers substantially use ICT for obtaining information on hybrid seeds, networking with co-farmers for sharing production experiences, and learning about technical procedures or artificial pollination processes.

Acknowledged importance of farmers' expertise of ICT use is affirmed as a mechanism opportuning access to technical support for optimised production of watermelon and cucumber in Nigeria in line with the ELT approach. Critically, the cognitive impact of experiences accumulated from interacting with ICTs rather engagement in horticultural production foster ICT use expertise as well as the consequent extent of application for facilitating production activities. This portends significant direction for scholarly debates on the viability of experiential approach to effective ICT use and the promotion in maximising the potential in transforming fruit vegetable production.

### Recommendations

1. Fruit vegetable farmers groups should be sensitised to prioritise self-help ICT appreciation training for their members.

2. Osun State Agricultural Development Programme (OSSADEP) should mandate agricultural extension officers to exemplify the potentials of varieties of ICTs through extension programmes and scheduled activities with farmers to enhance farmers' familiarity and consequent adoption of the ICT tools for production purposes.

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# THE ECONOMIC STRUCTURAL IMPACTS OF THE INDUSTRIALIZATION WAVE IN DEBRECEN

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**Abstract:** *Over the past decade, an intensive industrialization process has unfolded in Debrecen, driven primarily by foreign direct investment (FDI). Large-scale industrial investments—particularly projects in the automotive and battery industries—are fundamentally transforming the city's economic structure. The aim of the research is to examine how new industrial investments are altering Debrecen's manufacturing structure, as well as to what extent the emerging industrial structure differs from the previous economic structure. The empirical basis of the study is the manufacturing production database of the Central Statistical Office, as well as land-use data from companies operating in or relocating to Debrecen's two main industrial zones (the Southern Economic Zone and the Northwestern Economic Zone). During the research, I applied several empirical methods: the Herfindahl–Hirschman concentration index, shift–share analysis, and finally, the Location Quotient assessment. The results show that the new wave of industrialization is leading to significant industrial concentration. More than ninety percent of the manufacturing area in the industrial zones examined is linked to two industries—vehicle manufacturing and electrical equipment manufacturing. The significant increase in concentration indices indicates that Debrecen's economy is shifting toward a specialized industrial model. This process holds significant potential for economic growth, but it also increases the risk of economic vulnerability.*

**Keywords:** *Industrialization, Economic restructuring, FDI, Industrial cluster, Debrecen*  
(JEL code: R11, R12, O18, L60, L62)

## INTRODUCTION

Regional economic structural change is a fundamental phenomenon of economic development. As a result of globalization and international capital flows, the economic structure of cities may undergo significant transformation. This is particularly true for the Central and Eastern European region, where, following the transition, foreign direct investment played a key role in the transformation of the industrial structure.

In recent years, Debrecen has become one of Hungary's fastest-growing industrial centers. Large-scale industrial investments in the city—such as the BMW automobile plant and battery industry projects—have triggered significant economic and spatial changes.

The fundamental research questions of the study are as follows:

1. What industrial structure characterized Debrecen's economy prior to the new wave of industrialization?
2. In what direction are the new industrial investments transforming this structure?
3. What economic impacts and risks might the emerging industrial concentration entail?

## LITERATURE REVIEW

The issue of economic structural change has been extensively examined in the literature on regional economics and economic geography. According to Henderson's (1994) classic model, settlements of different sizes fulfill distinct economic functions in the spatial division of labor. Medium-sized cities often become centers of manufacturing production, particularly when they successfully integrate into global production networks.

In post-socialist countries, foreign direct investment played a significant role in the transformation of the industrial structure (Harloe, 1996). Investments by multinational corporations often introduce new industries to a given region, which can lead to rapid economic growth and technological development (Vida et al., 2025).

According to Porter's (1998) cluster theory, industrial concentration can promote productivity growth and innovation, as stronger knowledge flows develop among spatially concentrated firms. At the same time, excessive industrial specialization can also increase economic vulnerability, especially when the dominant industry is exposed to global economic fluctuations (Parkinson et al., 2016; Szobonya, 2025).

The study of regional economic restructuring has gained new momentum in recent years, particularly due to the transformation of global value chains, technological changes, and geopolitical tensions. The literature since 2020 increasingly emphasizes that foreign direct investment (FDI) is not merely a source of economic growth but one of the most important catalysts for the transformation of the regional industrial structure.

The latest empirical research has clearly demonstrated that FDI contributes to economic growth through multiple channels, particularly through technology transfer, job creation, and infrastructure development. (Chorneyi & Nelya, 2026). However, these effects do not manifest evenly across regions but are often highly concentrated, which can lead to regional disparities and inequalities (Molnár & Radics, 2024).

The 2026 OECD analyses highlight that FDI plays a key role in boosting regional productivity and strengthening innovation, particularly in regions capable of integrating foreign investment into the local entrepreneurial and innovation ecosystem (OECD, 2026). However, such integration is not automatic: it depends heavily on the quality of local human capital, infrastructure, and the institutional environment.

Recently published regional studies have also highlighted a reciprocal relationship between FDI and industrial structure: on the one hand, a more advanced industrial structure attracts foreign investment, and on the other hand, FDI itself contributes to the modernization and transformation of the industrial structure. (Wen et al., 2024). This interaction is particularly pronounced in metropolitan areas and during the formation of industrial clusters.

In the 2025 research also emphasizes that the regional concentration of FDI has a dual effect. On the one hand, it promotes economic growth and structural transformation; on the other hand, however, it can increase territorial inequalities and economic dependence. (Khdar & Ciešlik, 2025). This is particularly relevant in the Central and Eastern European region, where foreign investment is often concentrated in a few key industrial hubs.

The theory of global value chains (Global Value Chains – GVC) also provide a key framework for understanding industrial restructuring. According to recent research, FDI enables regions to integrate into global production networks, facilitating technological catch-up and industrial upgrading (Li & Adam, 2026). At the same time, the success of such integration depends heavily on local innovation capacities and the institutional framework.

Post-2020 literature on industrial policy and economic geography places increasing emphasis on the role of industrial clusters. Industrial clusters represent not merely geographical concentrations, but economic systems in which companies, suppliers, research institutes, and educational institutions are closely interconnected. The formation of such clusters can significantly boost the competitiveness of the regional economy, yet it also carries the risk of excessive specialization (Gereffi, 2020; Porter, 1998).

The latest global trends indicate that FDI is increasingly directed toward strategic industries—such as the battery industry, semiconductor manufacturing, and digital infrastruc-

ture—which is significantly reshaping the international economic landscape (McKinsey Global Institute, 2025). This trend is particularly important in the case of Debrecen, where the rise of the electromobility industries aligns well with these global processes.

Overall, the literature from after 2020 clearly supports the view that industrialization driven by foreign direct investment simultaneously presents an opportunity for economic convergence and a risk through increased economic dependence. This duality is particularly important in the case of medium-sized cities like Debrecen, where the rapid transformation of the industrial structure can determine the trajectory of economic development in the long term.

## MATERIALS AND METHODS

The research is based on two data sources:

### Initial industrial structure

Based on KSH data (KSH, 2025b) the manufacturing sector in Debrecen and Hajdú-Bihar is relatively diversified, with several sectors holding significant weight:

- vehicle manufacturing
- pharmaceutical industry
- food industry
- machinery industry

This structure is the result of the stratification of multiple industrialization eras.

### Data sources:

- KSH manufacturing production data (KSH, 2025a)
  - Production values of companies with over 49 employees
- Estimation of the new industrial structure

Land use data for Debrecen industrial zones (Southern Economic Zone and the Northwestern Economic Zone.)

- Zoning plan + land registry data + field survey
- Classification of companies according to Statistical Classification of Economic Activities in the European Community (TEÁOR)

### Methodological approach

- Comparative structural analysis
- Use of proxy indicators (land use → future industrial weight)
- Analysis of sectoral concentration

This approach is consistent with the indirect estimation methods used in regional economic analyses (Nagy & Lengyel, 2016).

The first data source is the manufacturing statistics of the KSH, which contains the production value of companies operating in Hajdú-Bihar County by sector group.

The second data source is the land use database for Debrecen's industrial zones, which contains the land area occupied by companies in the Southern Economic Zone and the Northwestern Economic Zone (DMJV, 2025).

In the empirical analysis, it was applied the following methods:

- Herfindahl–Hirschman concentration index
- Shift–Share analysis
- Location Quotient

**RESULTS AND DISCUSSION**

Industrial concentration – based on the calculation of the Herfindahl–Hirschman index

The Herfindahl–Hirschman index is an indicator used to measure industrial concentration, consisting of the sum of the squares of the shares of individual industries.

$$HHI = \sum s_i^2$$

where:

$s_i$  is the share of the given industry in total industrial production.

I used the following basic data in the calculation:

- total industrial production: 636,000 million HUF
- vehicle manufacturing: 137,029 million HUF
- pharmaceutical industry: 113,634 million HUF
- food industry: 94,623 million HUF.

Based on the calculation, for the initial industrial structure,  $HHI \approx 0.15$ , which indicates a relatively low concentration, meaning this structure is diversified.

However, taking new industrial investments into account, the index value increased significantly to  $HHI \approx 0.43$ , indicating a significant increase in concentration. Vehicle manufacturing  $\approx 50\%$ , electrical equipment (battery industry)  $\approx 42\%$ , all others  $\approx 8\%$ . In other words, the HHI is as follows:

$$HHI = 0.5^2 + 0.42^2 + 0.08^2 = 0.25 + 0.1764 + 0.0064 = 0.4328$$

This means that: Debrecen’s industrial structure is highly concentrated overall, as it is dominated by two industries. In other words: the Herfindahl–Hirschman Index value of 0.43 does not reflect the concentration of individual industries, but rather the concentration of the entire manufacturing sector, indicating that the vast majority of economic output is concentrated in two dominant sectors! From an economic perspective, this indicates a strong positive correlation with increased efficiency and specialization. However, it also significantly increases the region's economic exposure. For example, if the automotive industry declines, the entire region will be affected by the negative consequences.

**Shift Analysis**

The shift–share analysis (often referred to simply as shift analysis) is a classic method in regional economics. It serves to break down the sources of a region’s economic growth. In other words, it shows to what extent the growth of an industry or region is a consequence of national trends, industry-specific characteristics, or local competitive advantages. The basic principle of shift–share analysis is that changes in an industry’s output value consist of three factors:

1. National growth effect (National share),
2. Industry structure effect (Industry mix),
3. Regional competitive effect

(Regional shift). The sum of these three components yields the total change.

$$\Delta E_i = E_i^0(g) + E_i^0(g_i - g) + E_i^0(g_{ri} - g_i)$$

where:

1. The national growth effect indicates how much growth would have occurred in the region even if it had only followed national economic growth. If this component is large, then the region’s growth is partly the result of the national economic cycle.

2. The sectoral structural effect indicates whether the given sector is growing faster or slower than the national average. If positive: the region is in a “strong sector.” If negative: the region’s sector is underperforming nationally.

3. The regional competitiveness effect indicates whether the region performs better or worse than the national average within the same industry. If positive: the region is more competitive. If negative: the region is at a competitive disadvantage.

The shift-share analysis is illustrated through the following example: The baseline datasets: KSH (2025a), (2025b) and (2025c) – value of industrial production by location (Hajdú-Bihar County, manufacturing sectors, based on 2025 data) is 137,029 million forints.

1. The initial value of Debrecen’s automotive industry is therefore 137,029 million HUF

2. National industrial growth: 0.05

3. National growth of the automotive industry: 0.10

4. Growth of Debrecen’s automotive industry: 0.20

1. The national impact is therefore

$$NS = 137,029 \times 0.05 = 6,851$$

2. The industry impact:

$$IM = 137,029 (0.10 - 0.05) = 6,851$$

3. The regional impact:

$$RS = 137,029 (0.20 - 0.10) = 13,703$$

$$\text{The total growth is: } 6,851 + 6,851 + 13,703 = 27,405$$

The results show that Debrecen’s industrial growth stems from a combination of three factors: The general industrial growth of the Hungarian economy increases production on its own. Debrecen relies on industries that are growing rapidly globally (automotive industry, electromobility). Debrecen is a particularly attractive location for investments:

**Location Quotient**

The Location Quotient (LQ) is one of the most commonly used indicators in regional economics. It measures to what extent a given industry is over- or underrepresented in a region’s economy compared to the national structure. In other words: it shows whether the region has specialized in a given industry, or not. The LQ formula:

Where:

LQ value meaning

$LQ < 1$  the industry is weaker in the region

$LQ = 1$  national average

$LQ > 1$  specialization

$LQ > 2$  strong specialization

The following section examines the LQ values in Debrecen, in the automotive industry, and in the battery manufacturing industry. Calculation for the automotive industry:

Total automotive industry:  $E=636,000$  million HUF, Debrecen/Hajdú-Bihar automotive industry: 137,029 million HUF

In other words, 21.5% of the region's industry is the automotive industry.

2. National ratio: Let us assume (based on the KSH industrial structure) that the national automotive industry accounts for 15%.

L/Q calculation:

This means that the automotive industry in Debrecen is 43% stronger than the national average.

Another indicator related to the battery industry:

According to TEÁOR, this sector falls under the category of electrical equipment manufacturing.

1. Regional ratio: According to land use data for new industrial parks: electrical equipment:

$E_i = 3,517,869$  m<sup>2</sup>, while total manufacturing area:

$E = 8,329,000$  m<sup>2</sup>.

Therefore: 42% of industrial parks belong to this sector! National ratio. In Hungary, the manufacture of electrical equipment occupies approximately 13% of the area.

L/Q calculation:

This means that in Debrecen, the battery industry is more than three times as significant as the national average. This indicates a very strong specialization. Together, the two LQ values show that Debrecen's economy is highly specialized in the automotive industry and electromobility. This is typically a sign of an industrial cluster forming. In calculating the Location Quotient, we compared regional and national industry shares. The results show that vehicle manufacturing accounts for approximately 40% more of Debrecen's economy than the national average ( $LQ \approx 1.4$ ), while the manufacturing of electrical equipment—which primarily includes investments in the battery industry—is overrepresented by more than three times ( $LQ \approx 3$ ). We will detail the positive and negative implications of this later.

The concentration indices and the results of the structural analysis clearly indicate that Debrecen's industrial structure is undergoing a significant transformation.

The previous industrial structure was relatively diversified. Within the manufacturing sector, several traditional industries—such as the food industry, the pharmaceutical industry, and the machinery industry—also played a significant role.

However, new industrial investments point toward the emergence of a much more concentrated structure. Based on land-use data, more than nine-tenths of manufacturing areas are used by two industries: vehicle manufacturing and electrical equipment manufacturing.

This shift means that Debrecen's economy is moving from a diversified industrial model toward a specialized industrial model.

Economic specialization often goes hand in hand with increased regional competitiveness. A concentrated industrial structure can facilitate:

- the formation of supplier networks
- the concentration of technological knowledge
- the development of industrial clusters.

However, excessive specialization can also increase economic vulnerability, especially when dominant industries are exposed to global economic fluctuations.

### International Comparison

Debrecen's industrial development is not a unique phenomenon in the Central and Eastern European region. Numerous medium-sized cities have become international industrial production centers in recent decades.

#### Győr

Győr's development was largely built on Audi's investment. The formation of the automotive cluster resulted in significant economic growth; however, due to industrial concentration, the city's economy is heavily dependent on the state of the automotive industry.

#### Kecskemét

Mercedes' investment created a similar industrial structure in Kecskemét. The city's economic performance grew rapidly, but the industrial structure became significantly concentrated.

#### Katowice region

In Poland, the Katowice Special Economic Zone followed a similar development path. Targeted industrial policy and infrastructure development attracted significant FDI investments.

#### Bratislava

The capital of Slovakia has become one of the most important centers of the European automotive industry, hosting several global automakers.

These examples suggest that the process underway in Debrecen is part of a broader regional trend: cities in Central and Eastern Europe are becoming important production sites within global industrial value chains.

Based on the results, Debrecen's economic development aligns well with international patterns of regional economic restructuring. According to the literature, medium-sized cities often become centers of manufacturing production, particularly when they successfully integrate into global value chains (Henderson, 1994).

The observed increase in concentration is consistent with Porter's (1998) cluster theory, which posits that industrial concentration promotes productivity growth, knowledge flow, and innovation. The concentration of the automotive and battery industries emerging in Debrecen shows signs of the formation of a classic industrial cluster.

Conversely, the literature also points out that this type of specialization can increase economic vulnerability. According to Parkinson et al. (2016), cities built around a single dominant industry are particularly sensitive to global economic cycles.

Examples from Central and Eastern Europe—such as Győr or Kecskemét—show that specialization in the automo-

tive industry leads to rapid growth in the short term, but can also create structural dependence in the longer term (Nagy & Lengyel, 2016).

## CONCLUSION

Based on the research findings, it can be concluded that Debrecen's economic structure has undergone significant and structural transformation in recent years. The new wave of industrialization—which is primarily linked to large industrial investments associated with foreign direct investment—has led to a strong concentration of the city's industrial structure. Empirical studies have shown that the degree of industrial concentration has increased significantly: the Herfindahl–Hirschman Index rose from approximately 0.15 to about 0.43. This change indicates that Debrecen's economy is shifting from a more diversified industrial structure toward a highly specialized industrial model.

Based on the analysis, the new industrial structure is dominated primarily by two sectors: vehicle manufacturing and the manufacture of electrical equipment, the latter primarily involving investments in the battery industry linked to the electromobility value chain. The Location Quotient values indicate that these two industries are significantly overrepresented in Debrecen's economy compared to the national average. This suggests that the city's economy is developing toward the formation of an industrial cluster organized around the electromobility industry.

Such a transformation of the economic structure can have positive effects in several respects. Increased industrial concentration can facilitate the formation of industrial clusters, which, according to the literature, can contribute significantly to the growth of the regional economy's competitiveness. The formation of clusters is often accompanied by a concentration of technological knowledge, the development of supplier networks, and an increase in knowledge flow and innovation among companies. This type of economic concentration can therefore boost productivity and the pace of economic growth in the long term.

Furthermore, the investments taking place in Debrecen can also contribute to the region's economic convergence. The previous industrial structure showed relatively modest industrial performance, and Hajdú-Bihar County's share of the country's industrial production remained low for a long time. However, new industrial investments can significantly increase the region's industrial output, its export capacity, and employment. The presence of large companies can also trigger a multiplier effect, which can generate further economic activity in the region through the expansion of supply chains.

At the same time, the concentration of the industrial structure carries not only economic opportunities but also significant risks. One of the most significant risks is the growing dependence on a single industry. If a city's economic performance is too heavily tied to a single industry or technology sector, changes in the global market can have a significant impact on the local economy. The automotive and electromobility industries are particularly sensitive to global economic cycles, technological changes, and shifts in the regulatory en-

vironment. This means that a potential decline in demand or a technological shift could also negatively affect the region's economic performance.

An economic model reliant on foreign direct investment (FDI) poses an additional risk. While FDI can generate significant economic growth, the strategic decisions of multinational corporations are often made at the level of global corporate networks and do not necessarily reflect local economic interests. This means that the relocation of production capacities or changes in global corporate strategies can have unpredictable consequences for the local economy.

The transformation of the economic structure can also bring about significant changes in the labor market. New industries generally require production at a higher technological level, which presupposes a workforce with higher qualifications. This process may increase demand for engineers and technology specialists, while simultaneously reducing the proportion of jobs requiring lower qualifications. Consequently, local education and training systems must adapt to changes in the industrial structure.

Economic restructuring may also pose environmental and infrastructure challenges. The battery industry and sectors related to electromobility have significant energy and water requirements, which may increase the environmental burden on the region. Rapid industrial growth may also place significant pressure on urban infrastructure, particularly the transportation network, energy systems, and the housing market.

Taking these impacts into account, several key tasks can be identified for regional economic policy. On the one hand, it is advisable to develop a strategy that supports the formation of industrial clusters and the expansion of supplier networks, with particular regard to the integration of domestic small and medium-sized enterprises. This can help ensure that the economic impacts of large-scale corporate investments are felt more broadly across the regional economy.

On the other hand, the development of educational and research infrastructure plays an important role. Strengthening engineering and technical training, as well as developing cooperation between universities and industrial companies, can help ensure that the region remains competitive in industrial production in the long term.

Finally, promoting economic diversification can also be an important goal. Although the current industrial specialization offers significant growth opportunities, in the longer term it is advisable to develop an economic development strategy that also supports the growth of other industries and service sectors. This can reduce economic vulnerability and contribute to the stability of the regional economy.

Overall, it can be concluded that Debrecen's industrial development marks the beginning of a significant economic transformation. Current trends hold significant potential for economic growth; however, to ensure long-term sustainability, economic policy measures are needed that can address the structural risks arising from rapid industrialization.

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