

The Institute of Food Economics and Consumption Studies  
of the Christian-Albrechts-Universität zu Kiel

**Impacts of Information Access and Adoption of Soil Fertility and Water Conservation  
Practices on Smallholder Household Welfare: Experimental Evidence from Uganda**

Dissertation

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## **Abstract**

Uganda, like much of Sub-Saharan Africa, relies heavily on rain-fed agriculture with minimal input use, making it vulnerable to climate shocks. High population growth has increased food demand and intensified pressure on land. Climate change effects, especially drought, and the recent COVID-19 pandemic have exacerbated food insecurity and poverty underscoring the urgent need to improve productivity. This has placed sustainable agricultural intensification practices such as integrated soil fertility and water conservation measures which enhance crop productivity and household welfare while conserving natural resources, at the forefront of research and policy. However, adoption rates remain low due to limited access to information and inefficiencies in the overstretched agricultural extension system. Extension services often target men, leaving women, who face greater barriers to accessing information and resources, with limited capacity to adopt these technologies, yet they are highly involved in food production. Banana, a leading staple crop that supports the livelihoods of millions of smallholder households in the country, is especially affected by drought stress and soil nutrient depletion, resulting in low yields, and its value chain is male-dominated. Our study implemented an extension-based campaign in Uganda's major banana-cultivating regions to address these challenges. The campaign, structured as a randomized controlled trial, promoted integrated soil fertility and water conservation practices namely, manure application, mulching, and trenches, using multiple communication channels, including audio (radio), audio-visual (videos, in-person trainings), and hands-on (farmer field days and demonstration trials) approaches. Using intent-to-treat analysis, the study assessed the impact of information access on the uptake of soil fertility and water conservation practices, empowerment, and household welfare, measured by yields, sales, incomes, and food security. Machine learning methods were used to account for treatment effect heterogeneity. Treatment-on-the-treated analysis was employed to evaluate the effectiveness of communication channels and the effect of soil fertility and water conservation technology adoption on household welfare. Resilience to climate and COVID-19 shocks was analyzed using the Resilience Index Measurement and Analysis (RIMA) framework, with growth regression assessing the campaign's buffering effect against shocks. The results show that access to information through the campaign significantly increased the adoption of soil

fertility and water conservation practices, individually and in combination, with the combined practices yielding the greatest welfare benefits. Furthermore, welfare gains were higher for farmers who participated in both audio-visual and hands-on training approaches than those relying solely on audio channels. The campaign empowered farmers, particularly women, whose empowerment significantly boosted technology adoption. Health and mobility-related shocks during the pandemic had the greatest negative impact on welfare, while ownership of productive assets, access to credit, and strong social networks were key contributors to resilience. The campaign mitigated the effects of shocks and supported recovery for participating households. These findings underscore the importance of integrating mass media, such as radio and video, into extension services to expand outreach and using audio-visuals and practical approaches to enhance adoption. Women's empowerment through access to information, land, and credit is critical for improving technology uptake and productivity. Decentralizing services, promoting income diversification through value addition, and ensuring that farmers have access to agricultural information, are essential for enhancing resilience and promoting sustainable livelihoods for smallholder households. By adopting these strategies, policymakers can strengthen smallholder farming systems, improve livelihoods, and build long-term resilience in Uganda's agricultural sector.

## **Zusammenfassung**

Uganda ist, wie viele Länder südlich der Sahara, stark auf Regenfeldbau angewiesen, was es besonders anfällig für Klimaschocks macht. Das hohe Bevölkerungswachstum hat den Nahrungsmittelbedarf erhöht und den Druck auf den Landbesitz verstärkt. Die Auswirkungen des Klimawandels, insbesondere Dürren, und die COVID-19-Pandemie haben die Nahrungsunsicherheit und Armut weiter verschärft und die Notwendigkeit einer Produktivitätssteigerung verdeutlicht. Dies hat nachhaltige landwirtschaftliche Intensivierungspraktiken wie integrierte Bodenfruchtbarkeits- und Wasserschutzmaßnahmen in den Fokus von Forschung und Politik gerückt, da diese die Produktivität und das Wohlergehen der Haushalte steigern und gleichzeitig die natürlichen Ressourcen schonen. Aufgrund des begrenzten Zugangs zu Informationen und der Ineffizienz des überlasteten landwirtschaftlichen Beratungssystems bleibt die Akzeptanz jedoch gering. Beratungsdienste richten sich häufig an Männer, sodass Frauen, die mit größeren Hürden beim Zugang zu Informationen und Ressourcen konfrontiert sind, diese Technologien nur eingeschränkt übernehmen können, obwohl sie einen großen Anteil an der Nahrungsmittelproduktion haben. Kochbanane, ein wichtiges Grundnahrungsmittel, das den Lebensunterhalt vieler Kleinbauernhaushalte in Uganda sichert, ist besonders anfällig für Dürre und Nährstoffmangel im Boden, was zu niedrigen Erträgen führt. Zudem wird die Wertschöpfungskette überwiegend von Männern dominiert. Um diese Herausforderungen anzugehen, führte unsere Studie eine Erweiterungskampagne in Ugandas wichtigsten Bananenanbaugebieten durch, die als randomisierte kontrollierte Studie konzipiert war. Integrierte Praktiken zur Bodenfruchtbarkeit und Wassereinsparung, insbesondere Düngerausbringung, Mulchen und Gräben, wurden über mehrere Kommunikationskanäle gefördert, darunter Audio (Radio), audiovisuelle Medien (Videos, persönliche Schulungen) und praktische Ansätze (Feldtage für Landwirte und Demonstrationsversuche). Mithilfe einer *Intent-to-Treat-Analyse* wurde untersucht, wie sich der Informationszugang auf die Anwendung von Maßnahmen zur Bodenfruchtbarkeit und zum Wasserschutz auswirkt, sowie auf die Stärkung der Rolle der Landwirte und ihr Wohlbefinden, gemessen an Erträgen, Verkäufen, Einkommen und Ernährungssicherheit. Methoden des maschinellen Lernens wurden eingesetzt, um die Heterogenität der Behandlungseffekte zu berücksichtigen. Eine *Treatment-on-the-Treated-Analyse* bewertete die Wirksamkeit der Kommunikationskanäle und den Einfluss der Einführung von Technologien auf das Wohlergehen der Haushalte. Die Widerstandsfähigkeit gegenüber Klima- und COVID-19-Schocks wurde mit dem *Resilience Index Measurement and Analysis (RIMA)*-Rahmen analysiert, wobei eine Wachstumsregression den

Puffereffekt der Kampagne bewertete. Die Ergebnisse zeigen, dass der Zugang zu Informationen durch die Kampagne die Anwendung von Bodenfruchtbarkeits- und Wassererhaltungsmaßnahmen sowohl einzeln als auch in Kombination deutlich erhöhte, wobei die kombinierten Maßnahmen die größten Wohlfahrtsgewinne erzielten. Zudem waren die Wohlfahrtsgewinne bei Landwirten, die sowohl an audiovisuellen als auch praktischen Schulungen teilnahmen, höher als bei denen, die nur auf Audiokanäle setzten. Die Kampagne stärkte vor allem die Frauen, deren Empowerment die Technologieübernahme deutlich förderte. Gesundheits- und mobilitätsbedingte Schocks während der Pandemie hatten die größten negativen Auswirkungen auf das Wohlergehen, während der Besitz von Produktionsmitteln, Zugang zu Krediten und starke soziale Netzwerke entscheidend zur Widerstandsfähigkeit beitrugen. Die Kampagne milderte die Auswirkungen der Schocks und unterstützte die Erholung der teilnehmenden Haushalte. Diese Ergebnisse verdeutlichen, wie wichtig es ist, Massenmedien wie Radio und Video in die Beratungsdienste zu integrieren, um die Reichweite zu erhöhen und die Akzeptanz zu fördern. Die Stärkung der Rolle der Frauen durch den Zugang zu Informationen, Land und Krediten ist entscheidend für die Verbesserung der Technologieakzeptanz und Produktivität. Die Dezentralisierung von Dienstleistungen, die Förderung der Einkommensdiversifizierung durch Wertschöpfung und der Zugang der Landwirte zu landwirtschaftlichen Informationen sind wesentliche Faktoren für die Stärkung der Widerstandsfähigkeit und die Förderung nachhaltiger Lebensgrundlagen für kleinbäuerliche Haushalte. Indem politische Entscheidungsträger diese Strategien umsetzen, können sie die kleinbäuerlichen Anbausysteme stärken, die Lebensgrundlagen verbessern und die langfristige Widerstandsfähigkeit des ugandischen Agrarsektors ausbauen.

# CHAPTER 1

## General Introduction

### 1.1 Introduction

The global population has been steadily increasing and is projected to grow by two billion, reaching approximately ten billion by 2050 (FAO, 2017; WPP, 2019). According to the World Population Prospects (WPP), over half of this growth is anticipated to occur in Africa (WPP, 2015), particularly in Sub-Saharan Africa (SSA), where the population is expected to double within the next three decades (WPP, 2019). With an annual population growth rate of three percent, Uganda ranks among the fastest-growing populations in both SSA and the world (WPP, 2015). The country's current population of 41 million is projected to increase two-and-a-half-fold by 2050, according to the Uganda Bureau of Statistics (UBOS, 2021).

The rapidly growing population in the region has led to increased demand for food, which, if unmet, could result in hunger, malnutrition, and food insecurity. Previous estimates indicate that one in four people in Africa lack sufficient food to lead an active and healthy life (FAO, 2017). Food production in the region is largely dependent on rainfall which is increasingly becoming unreliable exposing farmers to the drastic effects of climate change (Jayne et al., 2019). Recent studies show that Sub-Saharan Africa (SSA) accounts for approximately 50% of the world's extremely poor and 23.3% of the global undernourished population (FAO, 2017). In Uganda, 40% of the population is undernourished (IPC, 2017; NPA, 2018) and the country ranks among the poorest worldwide (UNDP, 2020). The concentration of population growth in the poorest nations poses significant challenges for governments to eradicate poverty and inequality, address hunger and malnutrition, improve basic service delivery, and achieve the Sustainable Development Goals (SDGs) (WPP, 2015).

The recent global COVID-19 pandemic severely impacted economies and livelihoods, particularly in developing countries with limited financial buffers and inadequate government resources to expand social protection for affected populations (Béné et al., 2021; World Bank, 2021). In Uganda, the pandemic intensified poverty and food insecurity due to widespread job losses and strict lockdown

measures that disrupted livelihoods (Kansiime et al., 2021; UBOS, 2021). The country implemented stringent control measures, including two lockdowns with complete closures of borders, schools, and particular businesses; night curfews; and bans on public and private transport as well as public gatherings. These measures caused significant economic stress, reducing income and purchasing power, with adverse effects on food security and hunger (Kansiime et al., 2021; Tallio, 2021). Addressing such challenges and achieving the SDGs related to eradicating extreme poverty, hunger, malnutrition, food insecurity, and gender inequality depends critically on enhancing agricultural productivity, particularly in developing nations (UN, 2015).

The economies of the developing countries in SSA are predominantly dependent on agriculture which accounts for over 60 percent of aggregate employment, and about 23% of the Gross Domestic Product (GDP) and its contribution is much higher in many countries in the region (Goedde et al., 2019). In Uganda, 68 percent of the populace is employed in agriculture and the sector contributes 24% of GDP (UBOS, 2021). Agriculture in the country is characterized by cultivation on small pieces of land usually averaging 2.5 acres, continuous cropping with little or no use of inputs, land degradation, and inherently low yields (Jayne et al., 2014; NPA, 2020). The mounting population pressure is associated with the shrinking size of most smallholder farms over time, and with more continuous cultivation of fields, contributing to land degradation, soil exhaustion, and unsustainable forms of agriculture (Jayne et al., 2014; UBOS, 2022). Increased demand for food and energy to sustain livelihoods and create income sources have added to the already high levels of unsustainable natural resource utilization in Uganda (World Bank, 2021). Thus, raising agricultural productivity is crucial to accelerating economic growth, reducing poverty and vulnerability, and improving the country's livelihoods.

## **1.2 Problem Statement**

Sustainable intensification practices, such as mulching, manure application, and trenches are recognized as effective strategies for enhancing agricultural productivity while conserving natural resources (Jayne et al., 2019; Kassie et al., 2015). Although extensive evidence highlights their direct benefits, including improved soil fertility and water retention (Kihara et al., 2022; Van Asten et al., 2011), alongside welfare gains such as increased yields, incomes, nutrition, and food security (Abdulai & Huffman, 2014; Hörner

& Wollni, 2021; Pan et al., 2018), adoption rates remain low, primarily due to limited access to information (Abdulai, 2023; Aker, 2011). The government extension system is responsible for providing agricultural information and services to farmers but is hampered by inefficiency caused by inadequate financing and understaffing. For instance, extension staff-to-farmer ratios are 1:831 in Tanzania (Mabaya et al., 2017), 1:1850 in Ghana (MoFA, 2019), and 1:2500 in Uganda (UBOS, 2020). Furthermore, a recent Uganda Bureau of Statistics (UBOS) Annual Agricultural Survey revealed that only 14% of farming households in the country accessed extension services (UBOS, 2022).

More so, extension services are often targeted primarily towards men, overlooking women who contribute significantly to agricultural production (Lecoutere et al., 2023). This limits women's access to productivity-enhancing technologies and reduces their participation in agricultural decision-making (Doss & Morris, 2001; Farnworth et al., 2018). Although extension officers assume men share information with their spouses, studies reveal intrahousehold information asymmetries, where men often withhold critical agronomic knowledge, leaving women uninformed, further impeding the adoption of agricultural technologies (Fisher & Carr, 2015). Achieving sustainable uptake of technologies requires more than involving women—it necessitates empowering them to participate in decision-making and ensuring they have access to the resources needed to implement these technologies effectively.

Various crops are cultivated in Uganda, with the East African Highland banana, referred to here as "banana," ranking among the top five (UBOS, 2022). Banana - cultivated by 56% of the households in the country - is a staple crop of critical importance for food security (UBOS, 2022). Uganda is the leading producer of the crop in East and Central Africa and has the highest per capita banana consumption globally (Kikulwe et al., 2018). Banana contributes 17% percent of the country's daily caloric intake (Fiedler et al., 2013) and serves as a primary income source for millions of farming households (Kikulwe et al., 2018; Mbabazi et al., 2021). Beyond its economic and nutritional significance, banana cultivation has environmental benefits, including mitigating soil erosion on steep slopes, maintaining soil structure, and providing shade for intercropped crops like beans, groundnuts, and coffee (Wairegi et al., 2010). Despite women's significant role in banana cultivation, the value chain remains

predominantly male-dominated, limiting women's access to the full economic benefits of the crop (Ajambo et al., 2020).

Banana farming faces several challenges that significantly impact productivity. Biotic constraints such as pests and diseases, and abiotic factors like drought stress and soil nutrient deficiencies, contribute to inherently low yields (Mbabazi et al., 2021; Van Asten et al., 2011; Wairegi et al., 2010). Poor soil fertility persists due to continuous production without adequate nutrient replenishment and nutrient offtake caused by increased banana sales (Wairegi et al., 2010). Prolonged dry spells exacerbate productivity losses by inducing moisture stress (Van Asten et al., 2011). Various soil fertility and water conservation measures, such as manure application, mulching, and digging trenches, have been recommended to mitigate declining soil fertility and water scarcity (Bationo et al., 2007; Kihara et al., 2022). However, uptake of these practices has been low primarily due to limited access to information regarding their implementation procedure, benefits, and costs. A study conducted in the banana systems in Uganda observed that farmers were keen to apply technologies perceived to offer multiple benefits such as enhanced productivity, water conservation, and soil fertility improvement but they were constrained largely by insufficient knowledge (Ochola et al., 2013).

To address the productivity and information gaps, an extension-based campaign was implemented as a component of the banana agronomy project in Uganda's major banana-cultivating regions. The project aimed at improving smallholder farmers' welfare by providing agronomic information to farmers thereby enhancing the adoption of the practices, and boosting banana productivity, household incomes, and food security. The campaign employed a combination of communication channels, including audio (radio talk shows), audio-visual (video screenings and lecture trainings), and hands-on approaches (demonstration trials and farmer field days). These channels delivered consistent information on integrated soil fertility and water conservation practices through a randomized controlled trial (RCT). In the RCT, the control group accessed information only via audio, while the treatment group received information through all communication channels. These complementary channels were chosen based on their demonstrated effectiveness in raising awareness, increasing knowledge, and the uptake of agricultural technologies (Harou et al., 2022; Kondylis et al., 2017; Van Campenhout et al., 2021). The

campaign supported the formation of gender-inclusive groups for knowledge sharing, collective marketing, saving, and access to credit. It actively involved women through decentralized training and ensured women hosted at least 40% of the demonstration trials.

### **1.3 Study objectives**

The main objective of this study is to examine the impact of an extension-based campaign on the welfare of rural smallholder households in Uganda. The specific objectives are:

1. To examine the impact of information flow on the adoption of soil-improving and water conservation measures, banana productivity, commercialization, and income of smallholder households.
2. To evaluate the impact of information access through the extension-based campaign on the adoption of the integrated soil fertility and water conservation technology package and the food security of rural farm households.
3. To analyse the campaign's impact on the farmers' empowerment and the mediating role of women's empowerment in the uptake of agricultural technologies.
4. To assess the resilience of farming households in the face of climate change and COVID-19-related shocks and the impact of the campaign intervention in facilitating recovery.

### **1.4 Significance of the study**

The study is highly significant due to its comprehensive focus on improving agricultural practices, household resilience, and empowerment of farmers. By promoting sustainable farming practices that enhance soil health and water efficiency, it provides strategies to boost farm income, achieve food security, reduce poverty, and guide policymakers in designing effective campaigns for widespread adoption. It highlights the role of integrated soil fertility and water conservation practices in improving the sustainability and productivity of small-scale farms, mitigating vulnerabilities to environmental degradation and erratic weather, and supporting SDGs related to zero hunger, sustainable agriculture, and climate action. The study also addresses gender dynamics, offering insights to design inclusive

agricultural programs that empower women, strengthen rural economies, and contribute to global gender equality goals by leveraging the untapped potential of women in agriculture. Additionally, it evaluates the campaign's role in helping households recover from shocks and build resilience against crises, providing a framework for future interventions aligned with global priorities for sustaining livelihoods amid uncertainty. With its multidimensional focus on productivity, empowerment, resilience, and sustainability, the study delivers actionable recommendations for policymakers and development agencies while addressing critical challenges such as climate change, food insecurity, gender inequality, and rural poverty. Its findings have broad applicability, particularly for smallholder farmers vulnerable to economic and environmental shocks.

### **1.5 Description of the Study Area**

The study was conducted in the major banana-producing regions in Uganda. The extension-based campaign was a component of the banana agronomy project, a five-year initiative that commenced in 2017. It was implemented through a randomized controlled trial across six major banana-growing districts in Uganda, namely, Nakaseke and Luwero in the central region, Kabarole and Bunyangabu in the mid-western region, and Isingiro, and Rwampara in the south-western region. One district from each region was randomly selected as the treatment district (Nakaseke, Bunyangabu, and Isingiro), with the other serving as the control (Luwero, Kabarole, and Rwampara). Within each treatment district, one subcounty was randomly selected as the treatment unit: Nakaseke subcounty in Nakaseke district, Rwimi in Bunyangabu, and Birere in Isingiro. Similarly, one subcounty from each control district was randomly selected as the counterfactual: Makulubita in Luwero, Busoro in Kabarole, and Rugando in Rwampara. These regions are among the leading producers of the East African Highland banana in Uganda (UBOS, 2022). Figure 1.1 shows the map of Uganda highlighting the study area.

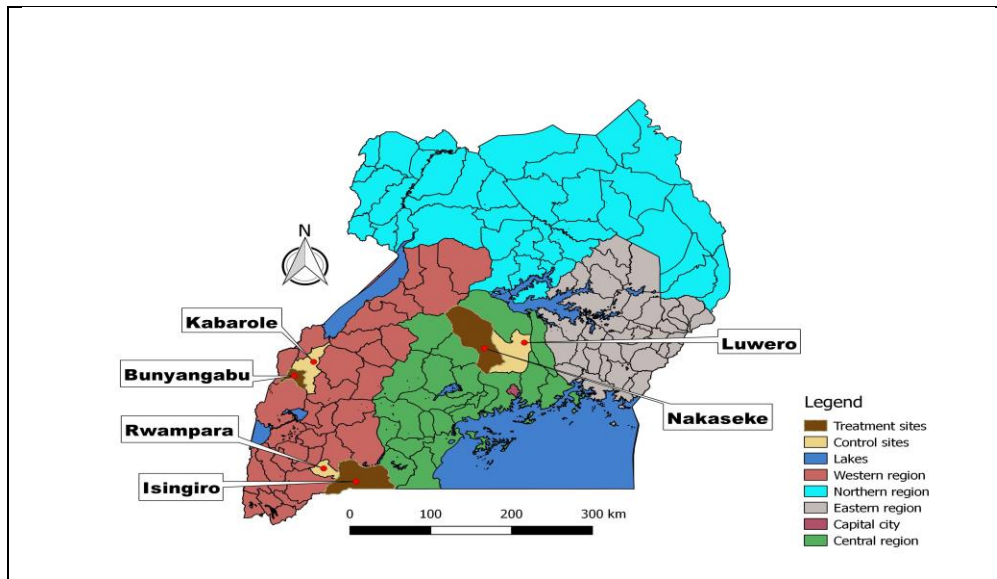


Figure 1.1: Map showing the study area.

## 1.6 Organization of the Thesis

This thesis is organized into six chapters as follows. Chapter one of the thesis presents the general introduction of the study. Chapters two to five are the collection of journal articles. Specifically, Chapter Two evaluates the impact of information flow on the adoption of soil-improving and water conservation measures, banana productivity, commercialization, and income of smallholder households. Chapter three examines the impact of the extension-based campaign on the uptake of the integrated soil fertility and water conservation technology package and the food security of rural farm households. Chapter four explores the campaign's impact on farmers' empowerment and the mediating role of women's empowerment in the uptake of agricultural technologies. The resilience of farming households in the face of climate change and COVID-19-related shocks alongside the impact of the campaign intervention in facilitating recovery are analyzed in chapter five. Chapter six presents the study's summary, conclusions, and policy implications.

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## CHAPTER 2

### **Information flow and the adoption of soil-improving and water conservation measures, and household welfare: Insights from a randomized controlled trial in Uganda**

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#### **Abstract**

Extension services are designed to facilitate the flow of information from researchers to farmers. However, information failures continue to impede the diffusion of soil-improving and water conservation technologies in Sub-Saharan African countries. We use a randomized controlled trial (RCT) to examine the impact of an extension-based campaign on the adoption of soil and water conservation measures and welfare outcomes among farmers in Uganda. The experiment involves the use of mass media including radio programs and video shows, lecture trainings, and practical sessions involving demonstration trials and farmer field days in disseminating information pertinent to soil-improving and water conservation practices. We compare the impact of utilizing audio-visual and hands-on approaches in disseminating information relative to audio means of communication. We employ machine learning techniques to analyze the heterogeneous effects and for covariate adjustment. We find that augmenting mass media in public extension has far-reaching effects. Our results reveal that transmission of information through multiple communication channels significantly increase the adoption of the soil-improving and water conservation measures. We also find that the intervention significantly increases welfare measures like banana yields, marketed surplus, and household incomes. These findings provide evidence that the use of mass media for increased awareness of improved technologies and utilizing audio-visual and hands-on communication channels in facilitating changes in attitudes and behavior of the end-users, can enhance the adoption of these technologies and contribute to increased household welfare.

*Keywords:* Information flow, Randomized Controlled Trial, Soil-improving and water conservation practices, Household welfare

## 2.1 Introduction

Climate change, with its impacts such as droughts and floods, presents a worldwide challenge, placing mitigation and adaptation measures at the forefront of global priorities. Sub-Saharan Africa, a region characterized by high population growth, high dependence on agriculture, and minimal use of soil-improving and natural resource conservation measures, faces the most drastic climate change effects (Kansiime et al., 2022). Continuous cropping without nutrient replenishment or organic amendments has led to soil depletion and declining productivity (Abdulai & Goetz, 2014; Nyombi et al., 2010). Reliance on mineral fertilizers is unsustainable in the long run since yearly crop harvests result in a decline in soil fertility due to nutrient extraction and loss in organic matter. Given the rising population coupled with shrinking farm sizes, rapidly degrading soils and climate change, it is imperative to consider the use of sustainable agricultural intensification practices that can increase yields and address current and future threats to food security, farmers' welfare, and ecosystem services (Shiferaw et al., 2013). These practices include soil-improving and water conservation measures like mulching, manure application, and drainage channels/trenches (Abdulai et al., 2011).

The adoption of soil-improving and water conservation practices enhances agricultural productivity and promotes environmental sustainability, which is crucial to achieving the goals of food security and poverty alleviation in Sub-Saharan African countries (Abdulai & Goetz, 2014; Pan et al., 2018). Hence, understanding the effects of interventions on sustainable farming practices and their impact on household welfare has huge implications for agricultural and environmental policy design (Rudolf et al., 2020; Vasilaky et al., 2023).

Earlier studies highlighted the role of secure property rights in encouraging investment in conservation measures (Abdulai et al., 2011; Besley, 1995; Ehui et al., 1990), while recent research emphasizes the importance of information transfer in facilitating the adoption of these practices (Kansiime et al., 2022; Pan et al., 2018; Rudolf et al., 2020). For example, Pan et al. (2018), demonstrated that information provision fosters adoption and improves productivity.

The lack of information and knowledge is one of the most frequently highlighted barriers to the adoption of agricultural innovations among smallholder farmers in developing countries (Abdulai, 2023; Aker,

2011; Baul et al., 2024; Harou et al., 2022). Furthermore, some of the adopted agricultural technologies are not implemented according to the recommended guidelines due to existing knowledge gaps (Hörner et al., 2019). In Sub-Saharan Africa, public agricultural extension systems are mandated to transfer information to end-users to enhance farmers' innovative capacity. However, as noted by the National Planning Authority (NPA) in Uganda, the public extension systems are under-resourced, leaving most farming communities underserved (NPA, 2018). Evidence from various countries indicates that the number of public extension officers is critically low. Statistics from Tanzania show a ratio of one extension officer to 831 farmers (Mabaya et al., 2017), in Ghana, the ratio is 1:1850 (MoFA, 2019), whereas in Uganda 2000 extension officers serve over five million farmers, translating to 1:2500 (NPA, 2018; UBOS, 2020). Such low staffing levels severely limit the diffusion and adoption of technologies through public extension services (Benin et al., 2011).

To reach wider audiences, agricultural extension systems have integrated information communication technologies (ICT) like mobile phones, radios, and videos. The effective use of ICT as complementary channels in agricultural extension for disseminating information broadly in the region has been widely documented (Abate et al., 2023; Baul et al., 2024; Van Campenhout et al., 2021). In Uganda, however, most documented experimental ICT agronomy extension studies focus on single-season interventions targeting annual crops like maize, rice, and beans, often using videos and electronic media like short message services (SMS) (e.g. Cai et al., 2014; Lecoutere et al., 2023; Van Campenhout, 2021; Van Campenhout et al., 2021). Videos engagingly blend audio and visual information making it easy for even illiterate farmers to grasp key concepts and they ensure message consistency across recipients (Baul et al., 2024). However, watching a video may be a passive exercise, increasing the likelihood that farmers would forget some of the details, particularly if there are multiple practices screened, some of which are complex, and if the lag between screening and implementation is long (Van Campenhout et al., 2021). When used in isolation, these methods may not suffice in the promotion of multiple technologies in the production of perennial crops like banana, which necessitate continuous engagement with the farmers while also involving in-person practical sessions to enhance knowledge retention (Parsa et al., 2014). To address this need, our study implements a randomized controlled trial (RCT) that

combines audio, audio-visual, and hands-on extension methods to disseminate agronomic information to smallholder banana farmers in Uganda. The combined dissemination methods are not merely additive; they possess unique features that synergistically enhance effective communication. Our study involving 471 smallholders examines how targeted information flow can boost farmers' adoption of soil-improving and water conservation practices and evaluates the impact of these practices on household welfare.

The intervention was designed to compare effects across combined channels relative to a single audio channel. Agronomic audio information was broadcast through radio stations with nationwide coverage, reaching out to farmers in the control and treatment groups. Additionally, the treatment group received audio-visual content, through video drama screenings and lecture trainings, alongside hands-on approaches including demonstration trials and farmer field days. This campaign-based approach, although common in public health and nutrition sectors (Rekhy & McConchie, 2014), remains underexplored in agricultural extension systems promoting soil and water conservation practices, particularly in experimental settings.

Our study makes several contributions to the literature. First, we estimate the causal impacts of campaign-based, multi-modal information delivery on the adoption of soil-improving and water conservation practices, extending the work of Pan et al. (2018), who evaluated the causal impacts of a large-scale agricultural extension program for smallholder women farmers on technology adoption in Uganda and Van Campenhout et al. (2021), who investigated the effectiveness of ICT-based agricultural information dissemination, including videos, SMS, and interactive voice response in the same country. Second, we assess the differential effects of single versus combined communication channels, highlighting that multiple modalities enhance adoption more effectively than a single channel. As Parsa et al. (2014) assert, leveraging multiple information dissemination channels can substantially enhance the adoption of natural resource conservation practices. Third, we estimate Local Average Treatment Effects (LATE) for the conservation practices to evaluate their direct influence on yield, marketed surplus, and household income. This causal analysis enables us to provide evidence-based policy

recommendations for analysts and policymakers focused on implementing natural resource conservation measures.

Unlike previous studies that primarily rely on observational data (e.g. Kansiime et al., 2022; Tambo et al., 2019), which are susceptible to endogeneity concerns, our RCT design enables robust causal inference. Our results reveal that transmitting information through multiple channels significantly increases the adoption of soil-improving and water-conservation practices and has positive and significant impacts on household welfare.

The remainder of the paper is structured as follows: Section 2 describes the study context and Section 3 highlights the experimental design. Section 4 outlines the data and empirical strategy. Section 5 presents results on the adoption of the practices and welfare impacts, and explores heterogeneous effects and the cost-effectiveness of the campaign intervention. Section 6 concludes with policy implications.

## **2.2 Context and study area**

Uganda is an agrarian country with a high population growth rate, estimated at 3.2% per annum, with about 73% of its populace living in rural areas and largely dependent on agriculture, which contributes 24% to the Gross Domestic Product (GDP) and 68% to aggregate employment (UBOS, 2021). Like in many other Sub-Saharan African countries, the provision of information to the farmers is part of the state's mandate. However, the public agricultural extension system is overstretched, characterized by few extension officers assigned to cover wide areas with limited facilitation (NPA, 2018). Development partners help to bridge the gap when they implement projects that provide smallholder farmers with information and knowledge, although these are not widespread and are usually short-lived (NPA, 2020). Lack of information due to inadequate extension services is a major constraint to adoption of soil-improving and natural resource management practices by smallholder farmers (NPA, 2018), resulting in lower yields for many key crops.

Banana is a priority perennial crop in Uganda, cultivated by one in every two households (UBOS, 2020). It is a primary source of food and income for millions of households (Mbabazi et al., 2021). Uganda is not only the leading banana producer in East and Central Africa but also has the highest per capita

consumption of the crop globally. Furthermore, banana cultivation provides significant environmental benefits within farming systems, as it mitigates soil erosion on steep slopes, preserves soil structure, and offers shade to intercrops such as beans, ground nuts, and coffee (Wairegi et al., 2010).

Despite its importance, the banana crop is affected by several biotic constraints, such as pests and diseases, and abiotic constraints like drought stress and soil nutrient deficiencies that have resulted in inherently low yields (Mbabazi et al., 2021; Van Asten et al., 2011; Wairegi et al., 2010). Poor soil fertility is a persistent problem because of continuous production without sufficient nutrient replenishment and nutrient loss via increased banana sales (Wairegi et al., 2010). The long dry spells leading to moisture stress compound low productivity (Van Asten et al., 2011). To boost productivity, various interventions have been implemented in the banana-producing regions in Uganda, though each targeted a specific constraint, and they were isolated in time and space. For example, Nyombi et al. (2010) conducted experiments with varying levels of mineral fertilizers, and they observed yield gains when the plants had adequate levels of the most critical nutrients, namely potassium and nitrogen. On the other hand, Van Asten et al. (2011) showed that effective management of drought stress through providing adequate water substantially improves yields. The current study improves on the previous approaches by tackling various constraints concurrently, promoting environmentally friendly practices.

Over the years, various soil-improving and water conservation measures, including manure and mulch application and drainage channels known as trenches, have been recommended to mitigate declining soil fertility and water shortage (Bationo et al., 2007; Kihara et al., 2022). Manure enhances soil nutrient content and organic matter, which improves soil structure, promotes better aeration, increases water infiltration, and enhances the soil's water-holding capacity (Bationo et al., 2007). These improvements collectively increase nutrient use efficiency, which is especially critical in the low-input banana farming systems common across the country's agroecological zones (Van Asten et al., 2011). Mulching suppresses weeds, offering a labor-saving benefit, and improves water infiltration and retention. Over time, mulch decomposes to release nutrients into the soil, contributing to higher yield (Ngetich et al., 2014). Trenches enhance rainwater infiltration and storage in the soil, reducing the adverse effects of drought stress, a major constraint in rain-fed banana production (Van Asten et al., 2011). While trenches

are more effective than mulch in capturing runoff and improving infiltration on sloping terrain, mulch is superior in minimizing soil water loss through evaporation (Kihara et al., 2022). Furthermore, mulch derived from external biomass sources, beyond the recycling of banana residues, introduces additional nutrients to the system. Combining mulch with manure enhances soil nutrient stocks more substantially than either input alone. Empirical evidence shows that while each of these soil-improving and water conservation practices contributes significantly to improving soil fertility, water use efficiency, and productivity, none of them on their own is sufficient in achieving all the requirements (Bationo et al., 2007; Kihara et al., 2022). Given their complementary effects, integrating manure, mulch, and trenches into an integrated soil fertility and water conservation (ISFWC) package will likely produce substantial productivity gains. For instance, Bationo et al. (2007) reported significantly higher yields when combining all three practices.

Although there is vast evidence suggesting positive yield returns, adoption of these practices by smallholder farmers has stagnated over the years and this has been primarily attributed to improper information dissemination (Adolwa et al., 2018) and knowledge constraints that lead to incomplete uptake of packages like ISFWC (Hörner et al., 2019). Poor communication of the performance and benefits of agricultural technologies to the end users has created wide communication gaps between the change agents and the farmers (Adolwa et al., 2018). Foster & Rosenzweig (2010) noted that such barriers to learning about correct technology usage or benefits constrain the adoption of seemingly basic practices like those considered in our study, namely, trenches, mulch, and manure application, especially when promoted as a package. Previous research shows that although farmers may simultaneously adopt several practices at the household level, they tend to employ them on different plots rather than combining them on one plot, and as such miss out on their synergistic potential (Hörner et al., 2019). Furthermore, we observed that some farmers in our study were excessively drying manure and applying it when it had lost most of its potential, while others were just scattering mulch without regard to the recommended depth/thickness. These sub-optimal practices would result in minimal yield improvements that normally discourage farmers. Additionally, extension activities typically focus on raising awareness about agricultural practices and offering guidance on how to implement them, but

they often overlook the importance of explaining why these practices are advantageous (Hörner et al., 2019). To address these concerns, we provided intricate details regarding each technology emphasizing “*the how*” and “*the why*” including the necessary materials and the mode of preparation (e.g., for manure), the appropriate timing for employing each practice, the optimal amounts, and the frequency of application that would minimize costs and maximize the benefits per unit area. We also highlighted the synergistic benefits of employing the three technologies jointly (ISFWC package). Our extension-based campaign uses multiple communication channels—including radio talk shows, video screenings, "lecture" trainings, demonstration trials, and farmer field days—to disseminate uniform information on the soil-improving and water conservation practices through a randomized controlled trial (RCT). We selected these complementary channels because they have been widely documented as effective means for increasing awareness, knowledge, and the adoption of agricultural technologies (Harou et al., 2022; Kondylis et al., 2017; Van Campenhout et al., 2021). Although we do not assess the effectiveness of each channel independently, previous experimental research shows that combining ICT-based extension approaches with in-person trainings has a significant impact on the uptake of farming practices (Lecoutere et al., 2023; Parsa et al., 2014).

The extension-based campaign was a component of the banana agronomy scaling project, aimed at improving smallholder farmers’ welfare by boosting banana productivity. To achieve the project’s objectives of reducing the yield gap and extension gap, information on several yield-enhancing agronomic practices was disseminated through the campaign, using multiple communication channels. The campaign was implemented with a team of scaling partners consisting of district local government extension officers, personnel from Non-Governmental Organizations, zonal agricultural research institutes, farmers’ associations, and media houses. Promotional items such as branded T-shirts and caps, posters, factsheets, and training manuals were developed and distributed to scaling partners.

The project started in 2017 in six major banana-growing districts of Nakaseke and Luwero in central, Kabarole and Bunyangabu in mid-western, and Rugando and Isingiro and Rwampara in south-western Uganda. These districts were selected because of their dominance in banana production in the country. One district from each region was randomly selected as the treatment (including Nakaseke, Bunyangabo,

and Isingiro) and the other as the control. In each treatment district, one subcounty was randomly selected as the treatment unit, including Nakaseke subcounty in Nakaseke district, Rwimi in Bunyangabu, and Birere in Isingiro, while one subcounty from each control district was randomly selected as the counterfactual. The control group consisted of Makulubita subcounty in Luwero, Busoro in Kabarole, and Rugando in Rwampara district. Figure 2.1 is a map of Uganda showing the study areas.

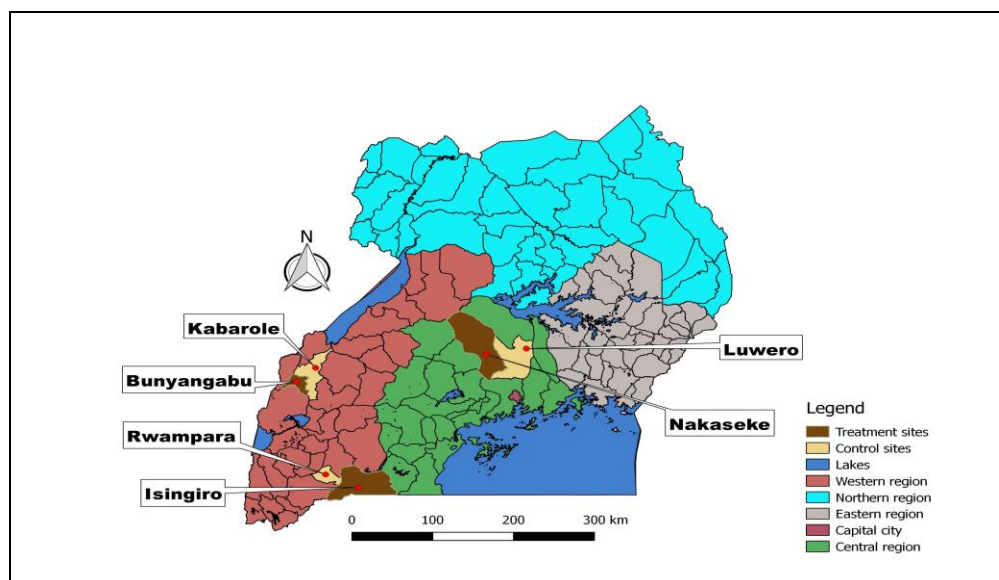


Figure 2.1: Map showing the study area.

## 2.3 Experimental design

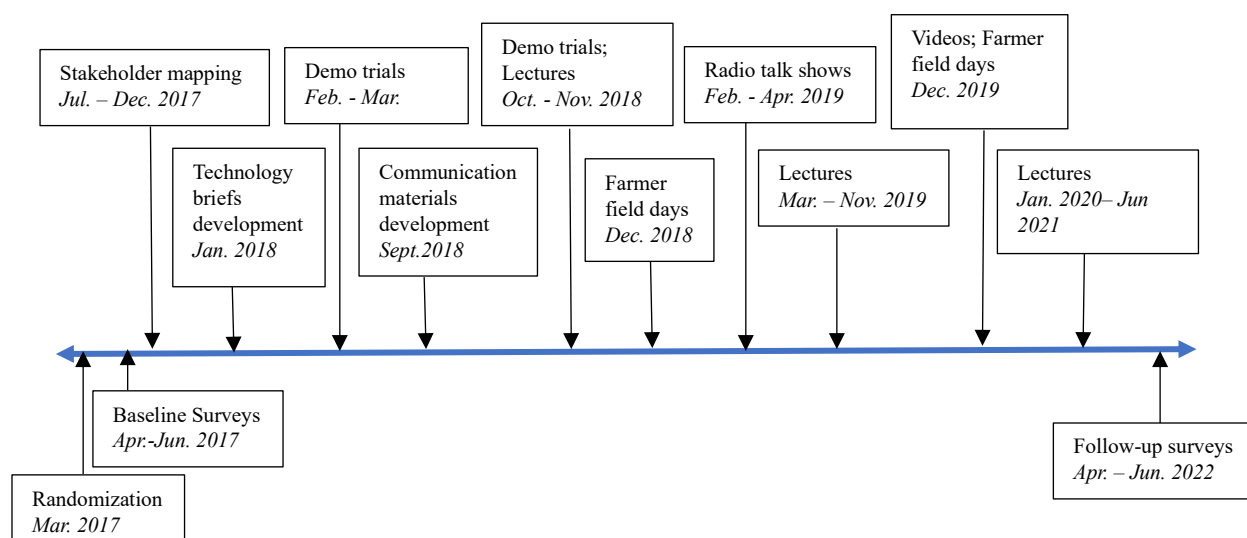


Figure 2.2: Timeline of the experiment

Figure 2.2 presents the timeline of the experiment. The study commenced with two baseline surveys. From March to April 2017, we conducted a socioeconomic survey among 471 randomly selected households to understand farmers' agronomic practices, their sources of agricultural information, yields, and household demographic characteristics. From April to June 2017, a team of agronomists carried out a biophysical survey among the same households to assess the agronomic practices in place and take allometric measurements in banana plantations for yield estimations. Between July and December 2017, we conducted stakeholder mapping and engagement through focus group discussions with farmers in the treatment sites to identify their sources of agricultural information, the type of information they received, how often they received it, and their preferred channels. We also contacted extension officers in the treatment sites and generated a list of stakeholders and scaling partners from these consultations. We held a stakeholders' workshop in January 2018, and another in September 2018, to develop a technology brief and communication materials respectively, that guided the implementation of the practices. The communication materials, including posters, fact sheets, a training manual, a story chart, a radio script, and a video drama script, had information on banana agronomic practices. Experts translated these materials into local dialects, after which we pretested, and refined before dissemination. We commenced the campaign with launches in the treatment sub-counties in February 2018. During these launches, the farmers highlighted and ranked the banana production constraints faced, and control measures employed and developed action points. Subsequently, using multiple channels, we disseminated information on the practices that farmers would use to combat the constraints. Both men and women attended the various trainings conducted.

### *2.3.1 Audio dissemination channel*

#### *2.3.1.1 Radio Talk Show*

We broadcast a twelve-week radio talk show from February to April 2019 via five radio stations, two with broad coverage in the central region, two based in the mid-western, and one in the south-western region. The coverage of these stations and the actual audience to the talk shows spanned across the major banana-growing regions in the country. Therefore, farmers within the treatment and the control sites were exposed to the radio broadcast. We selected the audio medium as the base channel because a

substantial portion of the sampled households (77%) at baseline owned and mentioned radio as a source of agricultural information. In addition to being a low-cost transmission means, the radio channel is effective in creating awareness among vast audiences (Dzanku et al., 2020), and it has been documented to spur technology adoption when utilized in a participatory manner (Perkins et al., 2011) and alongside audio-visual channels such as videos (Dzanku et al., 2020). Also, usually, various household members including women listen to the radio, especially in the evenings, regardless of who owns the radio, and this makes it an effective means while targeting a vast audience.

The broadcast was based on the radio script developed during the stakeholders' workshop. Each week, we aired a live 60-minute talk show in the local language, providing details about a specific agronomic practice, and allowing for live phone-ins from the listeners whose questions were answered on air. For increased interaction, listeners also responded to poll questions by sending a free SMS through the provided toll-free short code indicating their location and gender in addition to their answers. The poll questions explored constraints such as limitations to producing marketable banana bunches, and challenges faced in applying manure, and soil and water conservation practices. In total, 20,525 farmers from 56 districts responded to the poll questions, and a map of this listenership coverage is provided in Figure 2.4 in the appendix. The stations recorded each talk show and aired a repeat within the same week. Throughout the week, they aired adverts encouraging listeners to tune in. Focus group discussions with farmers in the treatment sites determined the radio stations and the best time for the program, based on the stations and shows most of the farmers listened to. Each talk show featured a panel of at least three people: a research team member, an extension agent, and a farmer.

### *2.3.2 Audio-visual dissemination channels*

#### *2.3.2.1 Video shows*

The research team contracted a filmmaker to produce the video drama "*Banana and I*" based on the script that was developed in the stakeholders' workshop. The video content was customized to the local context and featured native farmers in the community as role models, which stimulates the cognitive activity of the audience, and the experience of actual peers conveying messages, promotes attitude and behavior change (Bernard et al., 2015). In the 75 minutes drama, an extension officer trains farmers in

the various banana agronomic practices including soil-improving and water conservation measures with emphasis on how and when they should be done and their benefits. Furthermore, the households that employ the practices in their plantations obtain higher yields and improve their welfare more than those that do not apply the recommended practices. This conceptualizes the linkage between adoption, higher yields, and better incomes. Video screening took place in December 2019 using a projector and speakers. There were ten video screenings in each treatment site in communal areas like schools, churches, trading centers, and sports grounds. We had two shows per day, one in the afternoon and another in the evening. We mobilized the audience mainly through announcements aired through a megaphone moving through the villages two days prior to the screening. The viewers shared what they had learned and asked questions in an interactive discussion at the end of each show.

#### *2.3.2.2 Lecture trainings*

During the stakeholders' workshop, we developed a story chart, posters, and an extension manual, which were then used to facilitate farmer classroom/lecture trainings. The manual includes modules on various agricultural technologies, such as soil improvement and water conservation measures. The story chart presents good agronomic practices for banana production in the form of a story. In each treatment site, we recruited a site coordinator with a background in agricultural extension to coordinate project activities and disseminate information using these materials alongside scaling partners. The team conducted trainings fortnightly at parish level, mostly in communal areas such as schools, and at the premises of farmers hosting demonstration trials. The trainings took between 90 to 120 minutes.

#### *2.3.3 Hands-on dissemination channels*

##### *2.3.3.1 Demonstration Trials*

In our RCT, during the campaign launch in each treatment site, the farmers selected amongst themselves their preferred hosts for the demonstration trials. This has been observed as a vital facilitator for peer-to-peer learning among farmers (Sutherland & Marchand, 2021). We established the first set of demonstration trials in March 2018 and another in October of the same year. The research team alongside farmers and scaling partners established at least 40 demonstration plots showcasing various agronomic practices in each of the three treatment sites. The hosts and the local leaders mobilized

farmers in the neighborhood three days before the exercise. The sessions were highly participatory, with expert and peer discussions and hands-on engagements for each innovation. After establishment, the demos were monitored monthly by the extension agents and these plots acted as learning points, where more practical sessions were conducted.

#### *2.3.3.2 Farmer Field Days*

The project team worked closely with local committees involving district officials including the production department, political leaders, and scaling partners in organizing the farmer field days that took place in December 2018 and 2019. They held a radio talk show at a local station in each sub-county two days before the event to mobilize the farmers. This attracted between 350 to 700 farmers who participated in each treatment site. The primary objective of the farmer field days was to showcase the soil-improving and water conservation practices, their practical application and use, following site-specific recommendations. We registered<sup>1</sup> farmers and other participants on arrival and organized them into groups of 20 and took them through a study tour in the host farmer's plantation. There were several study points handling different conservation measures. We placed posters at each learning spot with a farmer, an extension officer, and a researcher practically demonstrating the practices.

#### *2.3.4 The relevance of multiple dissemination channels*

The use of multiple dissemination channels in our study is imperative because we focus on several technologies involving many procedures in the production of a perennial crop (banana). Explaining procedures such as manure preparation, the adequate moisture content of manure before application, or the illustration of the dimensions and gradient of trenches necessitate visualization to facilitate knowledge retention. Explaining such intricate details via the radio may increase awareness but may not suffice in driving the point home. Previous research has shown that the radio channel is effective in creating awareness across large audiences but may not suffice in influencing behavioral change (Dzanku et al., 2020). Furthermore, the radio talk show is restricted to just one hour, limiting the time available

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<sup>1</sup> During the campaign, attendance was recorded for each audio-visual and hands-on session indicating the name and gender of the participants and where they reside. The records indicate that those who attended demonstration trials and lecture trainings were based in the treatment sub counties. We did not observe any direct spillovers to the control group through any of these channels, since the control areas were quite distant from the treatment sites.

to answer questions from the audience or make clarifications compared to in-person sessions. In addition, the production of perennial crops that take more than one season to grow necessitates continuous nudges, and using different communication channels reduces the monotony and facilitates learning. More so, each dissemination channel facilitated adoption through a different mechanism. The video medium bolsters mindset change by portraying the adoption of the practices as a key component and prerequisite for improving household welfare. Exposure to on-farm demonstrations provides evidence of the outcomes of adoption, especially in terms of yield, and spurs broader uptake in the community through peer learning (Kondylis et al., 2017). Thus, using multiple dissemination channels provides different avenues that prompt farmers to adopt the technologies promoted.

## **2.4 Data, descriptive statistics, and estimation strategy**

### *2.4.1 Data*

During the socioeconomic baseline survey conducted from March to April 2017, we interviewed 471 households, 52% of which were in the treatment group. Within each of the six sub-counties, the respondents were selected using a random sampling approach from a comprehensive list of eligible banana-growing households provided by local council chairpersons. We used structured questionnaires to collect household and plot-level data, including household demographic, social, and economic characteristics, access to agricultural extension and sources of agricultural information, and the soil-improving and natural resource conservation practices. We conducted a follow-up survey between May and June 2022, in which we interviewed 430 households implying an attrition rate of nine percent. Although the attrition rate is low, we still test whether attrition bias is likely to influence the impact of the treatment as shown in Table 2.1A in the appendix. The coefficients are generally small in magnitude and the effect of attrition on the treatment is not statistically significant. Attrition was only slightly higher among households that own livestock. An F test with a p-value of 0.395 indicates that we cannot reject the null hypothesis that, jointly, attrition does not differ between the treatment and control groups.

### 2.4.2 Balance of randomization

Table 2.1 Descriptive statistics and balance tests

|   | Pooled Sample |        | Treatment group |        | Control group |        | Mean difference |
|---|---------------|--------|-----------------|--------|---------------|--------|-----------------|
|   | Mean          | SD     | Mean            | SD     | Mean          | SD     | Treated-Control |
| <u>Outcome variables</u>                  |               |        |                 |        |               |        |                 |
| Manure application (1=Yes)                | 0.425         | 0.495  | 0.398           | 0.491  | 0.453         | 0.499  | -0.055          |
| Mulch application (1=Yes)                 | 0.482         | 0.500  | 0.480           | 0.501  | 0.484         | 0.501  | -0.005          |
| Dug trenches (1=Yes)                      | 0.435         | 0.496  | 0.439           | 0.497  | 0.431         | 0.496  | 0.008           |
| ISFWC practices (1=Yes)                   | 0.144         | 0.352  | 0.118           | 0.323  | 0.173         | 0.379  | -0.055*         |
| Banana yield in ton/acre                  | 3.309         | 2.930  | 3.482           | 3.300  | 3.121         | 2.457  | 0.361           |
| Marketed surplus (banana proportion sold) | 0.333         | 0.276  | 0.344           | 0.268  | 0.320         | 0.283  | 0.024           |
| Annual household income (million UGX)     | 4.745         | 8.676  | 5.413           | 9.437  | 4.015         | 7.714  | 1.399*          |
| <u>Control variables</u>                  |               |        |                 |        |               |        |                 |
| Household size                            | 4.894         | 2.161  | 5.025           | 2.191  | 4.751         | 2.124  | 0.273           |
| Gender of household head (1=Male)         | 0.781         | 0.414  | 0.809           | 0.394  | 0.751         | 0.433  | 0.058           |
| Age of household head (years)             | 50.798        | 14.882 | 50.000          | 14.126 | 51.671        | 15.652 | -1.671          |
| Household head's years of education       | 6.342         | 4.269  | 6.289           | 4.256  | 6.400         | 4.292  | -0.111          |
| Total land owned (acres)                  | 5.616         | 9.990  | 6.636           | 10.939 | 4.501         | 8.726  | 2.136**         |
| Household head is a farmer (1=Yes)        | 0.851         | 0.356  | 0.870           | 0.337  | 0.831         | 0.375  | 0.039           |
| Household owns a motorcycle (1=Yes)       | 0.195         | 0.397  | 0.244           | 0.430  | 0.142         | 0.350  | 0.102***        |
| Household owns a bicycle (1=Yes)          | 0.533         | 0.499  | 0.541           | 0.499  | 0.524         | 0.501  | 0.016           |
| Household owns a phone (1=Yes)            | 0.856         | 0.352  | 0.862           | 0.346  | 0.849         | 0.359  | 0.013           |
| Household owns a radio (1=Yes)            | 0.766         | 0.424  | 0.752           | 0.433  | 0.782         | 0.414  | -0.030          |
| Household owns a television (1=Yes)       | 0.206         | 0.405  | 0.220           | 0.415  | 0.191         | 0.394  | 0.028           |
| Log of total value of assets              | 13.164        | 2.320  | 13.384          | 2.308  | 12.924        | 2.314  | 0.459**         |
| Tropical Livestock Units (TLU)            | 1.439         | 6.252  | 1.683           | 8.345  | 1.172         | 2.392  | 0.511           |
| Credit access-not constrained (1=Yes)     | 0.569         | 0.496  | 0.606           | 0.490  | 0.529         | 0.500  | 0.077*          |
| Belong to a farmer group (1=Yes)          | 0.463         | 0.499  | 0.472           | 0.500  | 0.453         | 0.499  | 0.018           |
| Number of observations                    | 471           |        | 246             |        | 225           |        |                 |

SD is the standard deviation. \*, \*\*, \*\*\* denote that the difference is at 10%, 5% and 1% level, respectively.

Table 2.1 shows the descriptive statistics and presents covariate balancing tests that assess the effectiveness of the randomization procedure. Our results provide evidence that the randomization procedure was balanced across the treatment and control groups, since most of the baseline variables are not significantly different between the two groups, which implies that randomization bias, which is common in small samples, is not a major concern in our study (Athey & Imbens, 2017). Utilization of

the soil-improving and water conservation measures is balanced across the treatment and control groups. Similarly, the welfare outcomes namely yield, marketed surplus, and household incomes are also balanced in both groups. A few covariates including total land owned, ownership of a motorcycle, and the total value of assets are not balanced, hence we include baseline covariates in the analyses to improve the precision of the estimates.

Although adoption of the practices at baseline seems moderate (between 40-48%), less than 10% of the households were implementing the practices following the recommended guidelines. For instance, only 6% of those who were applying mulch were aware of and implementing the recommended mulch depth of 8-15cm and placement of 1.5-2 feet away from the plants. We aimed to address such prevailing knowledge gaps through our intervention. Furthermore, there were other constraints such as low farm-gate prices limiting the adoption of practices that require cash investment. We addressed these by facilitating the organization of farmers in cooperatives/ collective marketing groups to increase their bargaining power and linkage to traders who offered higher farm-gate prices than the middlemen who were exploiting them. Through these cooperatives, the farmers were also able to access credit to purchase inputs such as manure.

#### 2.4.3 Estimation Strategy

We estimate the impact of the interventions using the single difference model, which is a comparison of the treatment and control groups in the following specification.

$$Y_{ij1} = \alpha_1 + \beta_T Treatment_j + \beta_X X_{ij0} + \gamma D_d + \varepsilon_{ij1} \quad (1)$$

where  $Y_{ij1}$  is the outcome variable of interest for farm household  $i$  in subcounty  $j$  at follow-up;  $\beta_T$  is the intention-to-treat (ITT) effect associated with the information dissemination interventions;  $X_{ij0}$  is a vector of baseline explanatory variables;  $D_d$  is a vector of district level dummies, with  $\gamma$  as a parameter vector to be estimated, and  $\varepsilon_{ij1}$  is the error term. The ITT estimates were identified by the difference between the treatment and control groups during the intervention period. This specification is reported as the Simple Mean Difference (SMD) in the results tables (Tables 2-12).

In instances like ours with a single baseline and follow-up survey, an analysis of covariance (ANCOVA) produces more precise estimates than the difference-in-differences (DID) method (McKenzie, 2012). The ANCOVA specification is the same as the one shown in equation (1), except that it includes the baseline values of the outcome variable as a control. If autocorrelation is low, implying that the baseline and endline values of the outcome variable are weakly correlated, then using ANCOVA increases the power and efficiency. Through simulations, McKenzie (2012) shows that ANCOVA provides smaller standard errors and higher power when autocorrelation is below 0.5 compared to the DID. The autocorrelation of all our outcomes is low except for trenches (0.522) and marketed surplus (0.514) as shown in Table 2.2A in the appendix, and this justifies our use of ANCOVA. The model is specified as follows.

$$Y_{ij1} = \alpha_1 + \beta_T Treatment_j + \beta_X X_{ij0} + \beta_Y Y_{ij0} + \gamma D_d + \varepsilon_{ij1} \quad (2)$$

where  $Y_{ij0}$  is the baseline value of the outcome, the rest of the parameters are as described in equation (1).

The ITT estimates provide an outlook of the development impact without full compliance; hence they are important for policymakers because most development programs offer training or other services but cannot enforce full compliance. The ITT effects do not account for possible non-compliance, a situation whereby not all farming households in the communities with the interventions participate in the sessions. Non-compliance is better accounted for by the average treatment effect on the treated (ATT), which measures the actual effect of training attendance (Duflo et al., 2007). We did not observe perfect compliance in our study<sup>2</sup>, so we also estimate the ATT, using actual training attendance<sup>3</sup> as a treatment variable, and four specifications are considered. In the first specification (ATT), the training attendance dummy takes a value of one if a household attended any training/information dissemination session and zero if they did not attend any. In the second specification, (ATT 1), the training attendance dummy

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<sup>2</sup> Twenty percent of the households in the treatment group did not participate in any session, which constitutes non-compliance.

<sup>3</sup> Approximately 68 percent of treatment group respondents reported listening to the campaign's radio programs, compared to 45 percent in the control group. Of those within the treatment group who participated in the sessions, 35 percent participated in the audio-visual sessions, 35 percent attended the practical sessions, whereas 42 percent participated in both.

takes a value of one if a household attended any session offered through lecture trainings and/or video shows, and zero otherwise. In the third specification (ATT 2), training attendance is equal to one if a household participated in practical sessions offered through farmer field days, and/or demonstration trials, and zero otherwise. With the fourth specification (ATT 3), the training attendance dummy equals one if a household participated in both audio-visual and practical sessions, and zero otherwise. The decision to attend training sessions is potentially endogenous, so we use the two-stage least squares (2SLS) approach which utilizes instrumental variables (IV) to deal with the potential endogeneity bias. We rely on the random assignment into the treatment groups as a valid instrument. The ATT effects are unbiased when the offer to participate in the treatment is random (random assignment of districts to treatments) and the offer to participate in the treatments is highly correlated with actual training attendance (Angrist et al., 1996). The offer to participate in the treatment should not be correlated with the outcome, except through the actual attendance of the sessions.

We also estimate the Local Average Treatment Effect (LATE) for the conservation practices by analyzing the uptake of conservation practices as the endogenous regressor. This reveals the effect of adopting the soil-improving and water conservation practices on household welfare.

Including covariates is likely to increase the precision of the estimates, if the covariates are sufficiently correlated with an outcome (Athey & Imbens, 2017). To determine the covariates to include in the regressions, we utilize the post-double selection (PDS) least absolute shrinkage and selection operator (LASSO) procedure, which prevents p-hacking and overfitting the models by omitting control variables that are not sufficiently correlated with treatment status, thereby yielding more parsimonious estimates (Belloni et al., 2014). Although the PDS-LASSO<sup>4</sup> is often used in high dimensional settings, it can still be used in moderate sample sizes to avoid overfitting and control for important variables provided that the number of predictors is not overwhelmingly large (Belloni et al., 2014).

A potential pitfall related to inference in our study is drawing multiple outcomes of interest from the same data set which is likely to cause a type 1 error. This is common in experimental studies where

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<sup>4</sup> We conduct this procedure in Stata 18 using the *pdslasso* command for the ITT estimates and *ivlasso* for the ATT estimates where we instrument ex-post treatment using ex-ante assignment to treatment.

significant results may occur due to chance, even though the treatment may have no effect on any of the outcomes of interest. Therefore, the null hypothesis may be rejected when it is true, due to multiple hypotheses testing. To address this concern, we control for the false discovery rate (FDR), which is the share of null hypotheses rejections that are false positives, by applying the sharpened two-stage q-values approach (Anderson, 2008). We also present the results of all the hypotheses tests under randomization-based inference (RI), which enables us to estimate the exact p-values under the sharp null of no treatment effect following Young (2019). The RI  $p$  values are calculated involving random reassignment of treatment and re-estimation of the coefficient multiple (2,000) times. We utilize RI because it is a useful technique when the method of randomization is known and when the sample size is small, as in the present study (Young, 2019).

#### *2.4.4 Treatment heterogeneity*

Policymakers and analysts are normally interested in heterogeneous treatment effects for policy purposes. In this study, we examine potential sources of heterogeneity in our treatment effects to determine whether the average impact of the campaign concealed any variations in response to treatment. The effects were estimated using generalized random forest, which is a machine learning technique that utilizes causal forests to detect heterogeneous treatment effects. This method yields unbiased estimates of the heterogeneous treatment effects, which are individualized predictions of treatment effects. We analyze the impact heterogeneity across all the control variables that are listed in the descriptive statistics in Table 2.1.

#### *2.4.5 Ex-post power calculations*

To determine whether an experiment was designed to have sufficient power to detect a given effect size, we report the ex-post Minimal Detectable Effects (MDEs) based on the realized sample size and estimated standard errors of the effects in the study, following McKenzie & Ozier (2019) and Buehren et al. (2025). Since ANCOVA increases the power and efficiency of the estimations (McKenzie, 2012), we examine the ex-post MDEs for all our outcomes given our realized sample size per cluster and estimated standard errors at follow-up for the ANCOVA estimates. That is, given our study design of 3 clusters in the control group and 3 clusters in the treatment group, with a varying number of households

in each cluster, we ask, how big of an impact would we have needed to have been powered to detect an effect, assuming a power level of 80% and significance level 0.05?

The results in Table 2.6A in the appendix show that the study has adequate statistical power to detect intent-to-treat (ITT) effects on the adoption of manure, mulch, and the ISFWC package, as well as all the welfare outcomes. It was slightly underpowered for detecting ITT effect for the uptake of trenches, possibly the reason why this effect is not significant based on conventional p-values. However, considering the main focus of our paper, assessing the impact of participation in the various sessions (ATT), the study was adequately powered to detect effects on all the adoption and welfare outcomes.

## **2.5 Results**

### *2.5.1 Adoption of soil-improving and water conservation measures*

In this section, we report the results of our assessment of the impact of our information campaign on the uptake of the soil-improving and water conservation practices namely manure, mulch, trenches, and a package of the three combined, and denoted as ISFWC (integrated soil fertility and water conservation). Smallholder farmers decide to adopt new or improved technologies when they have adequate information about the benefits and suitability of the various integral aspects of the technologies (Abdulai, 2023; Conley & Udry, 2010). Our analysis reveals how this information translated into practice adoption across treatment and control groups. As shown in Figure 2.3, there was increased uptake of the soil-improving and water conservation measures between the baseline and follow-up periods in both the treatment and control groups, with the notable exception of manure, where a slight decline is observed among the control group. Generally, higher levels of uptake are observed in the treatment group compared to the control. Specifically, out of the entire sample, 13%, 17%, 19%, and 18% more households in the treatment group adopted manure, mulch, trenches, and a combination of the three practices, respectively, by the time the follow-up survey was conducted. Figure 2.3 illustrates a consistent increase in adoption across all practices in the treatment group, with mulch showing the largest gain.

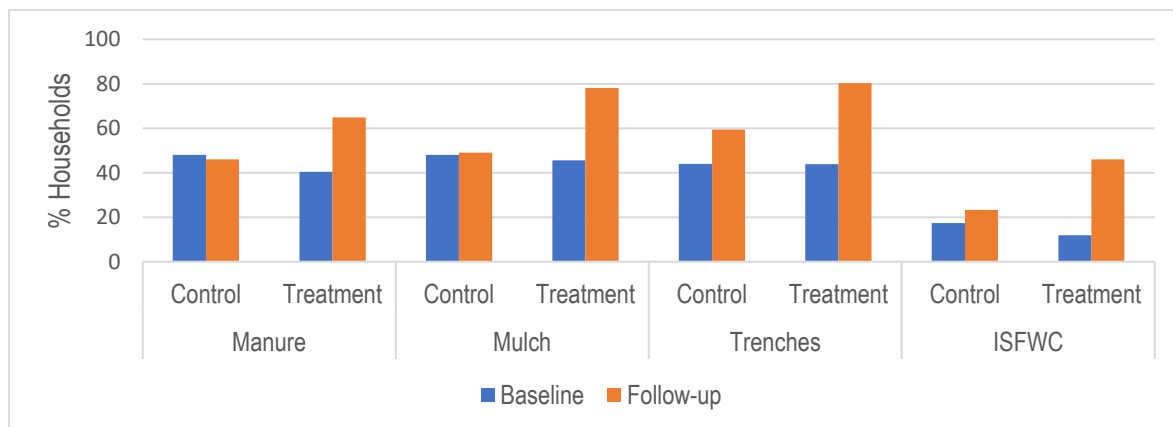


Figure 2.3: Uptake of soil-improving and water conservation practices in treatment and control groups (n=430)

### 2.5.2 Impact of information access on the uptake of the practices

Next, we present the treatment effects on the uptake of the soil-improving and water conservation practices (ITT) and the average treatment effects on the treated (ATT). Both the simple mean difference (SMD) and analysis of covariance (ANCOVA) are estimated. In all cases, inference is based on subcounty-level clustered standard errors and  $p$  values adjusted for multiple hypothesis testing in curly brackets. We also present  $p$ -values based on randomization inference, i.e.,  $RI$   $p$ -values in diamond brackets. Each table also contains estimates without covariate adjustment (Panel A) and with covariate adjustment (Panel B). The covariates selected through this procedure are listed in Tables 2.4A and 2.5A in the appendix.

The ITT results in Table 2.2 show that agricultural information delivery through the campaign significantly influenced the adoption of the soil-improving and water conservation measures. In particular, the results of the SMD and ANCOVA are quite similar, with the ANCOVA analysis showing positive and statistically significant correlations between baseline and follow-up values of the outcome variables in most of the estimations (coefficients shown in Table 2.3A in the appendix), implying that the baseline value explains a large proportion of the variance in the follow-up value. Hence, including the baseline values of the outcome variables tend to improve the power of most of the estimations in our analysis.

Table 2.2 Effects of the extension-based campaign on the adoption of soil-improving and water conservation measures

|              | Manure  |         | Mulch   |         | Trenches |         | ISFWC   |         |
|--------------|---------|---------|---------|---------|----------|---------|---------|---------|
|              | SMD     | ANCOVA  | SMD     | ANCOVA  | SMD      | ANCOVA  | SMD     | ANCOVA  |
| Panel A      |         |         |         |         |          |         |         |         |
| ITT          | 0.162   | 0.153   | 0.207   | 0.217   | 0.044    | 0.047   | 0.117   | 0.117   |
|              | (0.031) | (0.025) | (0.016) | (0.016) | (0.027)  | (0.025) | (0.025) | (0.025) |
|              | [0.003] | [0.002] | [0.000] | [0.000] | [0.172]  | [0.116] | [0.006] | [0.005] |
|              | {0.002} | {0.001} | {0.001} | {0.001} | {0.026}  | {0.017} | {0.003} | [0.002] |
|              | ⟨0.003⟩ | ⟨0.001⟩ | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.166⟩  | ⟨0.103⟩ | ⟨0.005⟩ | ⟨0.007⟩ |
| Observations | 430     | 430     | 430     | 430     | 430      | 430     | 430     | 430     |
| Control mean | 0.460   | 0.460   | 0.490   | 0.490   | 0.594    | 0.594   | 0.233   | 0.233   |
| Panel B      |         |         |         |         |          |         |         |         |
| ITT          | 0.191   | 0.190   | 0.237   | 0.244   | 0.050    | 0.049   | 0.135   | 0.136   |
|              | (0.002) | (0.003) | (0.001) | (0.002) | (0.000)  | (0.000) | (0.000) | (0.001) |
|              | [0.000] | [0.000] | [0.000] | [0.000] | [0.000]  | [0.000] | [0.000] | [0.000] |
|              | {0.001} | {0.001} | {0.001} | {0.001} | {0.001}  | {0.001} | {0.001} | {0.001} |
|              | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩  | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩ |
| Observations | 430     | 430     | 430     | 430     | 430      | 430     | 430     | 430     |
| Control mean | 0.460   | 0.460   | 0.490   | 0.490   | 0.594    | 0.594   | 0.233   | 0.233   |

Notes: ISFWC is a package combination of manure, mulch, and trenches. SMD is the Simple Mean Difference. ANCOVA is Analysis of Covariance. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), based on 2,000 draws, are in ⟨diamond brackets⟩. FDR denotes false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively.

As shown in Table 2.2, on average, the information dissemination intervention increased the use of manure by between 15-16 percentage points (Panel A) and 19 percentage points (Panel B) all of which are statistically significant at the 1% level, even after multiple inference correction. The intervention also significantly increased the uptake of mulch by between 21-22 percentage points without covariate adjustment, and to 24 percentage points with covariate adjustment. Conversely, there is no significant effect on the adoption of trenches, when all the covariates are considered (Panel A) and the estimates do

not survive RI correction. However, with covariate adjustment (Panel B), the effect is significant at the 1% level, and it is about five percentage points and six percentage points higher than the control for trenches. The adoption of the package of the three practices combined (ISFWC) significantly increased by between 12 and 14 percentage points without and with covariate adjustment respectively, even after accounting for FDR and RI correction. These findings are consistent with the results from Pan et al. (2018), who showed that farmers residing in eligible villages are 9.2 percentage points more likely to use manure, while Hörner et al. (2019) found that farmers in the treatment groups were 14.3-19.2 percentage points more likely to adopt compost manure and 8.4-10.9 percentage points more likely to adopt the integrated soil fertility management package compared to those in the control group.

Tables 2.3-2.6 report the ATT, which is the impact of actual participation in the sessions. The attendance of any training session (Table 2.3) has a positive and significant impact on the adoption of each practice and the ISFWC package without covariate adjustment (Panel A).

Participation in either audio-visual sessions (Table 2.4) or hands-on sessions (Table 2.5) increased uptake of each of the practices, as well as the package, although the effect is generally only significant at the 10% level when covariates adjustment is done alongside randomization inference correction. Furthermore, the levels of adoption of the practices are slightly higher among those who attended the audio-visual sessions than those who participated in the hands-on sessions. This finding is somewhat surprising because human beings are likely to learn better by doing (Sutherland & Marchand, 2021). However, it is important to note that the audio-visual sessions involved the continuous use of illustrations such as posters and story charts in the lecture trainings. Also, through the video medium, farmers can visualize and memorize the content shown (Van Campenhout et al., 2021) and featuring their peers in the video conveying messages promotes attitude and behavior change (Baul et al., 2024; Bernard et al., 2015; Rudolf et al., 2020). This could have facilitated retention of information and subsequent adoption of the soil-improving and water conservation practices.

Table 2.3 Effects of participation in any training session on the adoption of soil-improving and water conservation measures

|         | Manure  |         | Mulch   |         | Trenches |         | ISFWC   |         |
|---------|---------|---------|---------|---------|----------|---------|---------|---------|
|         | SMD     | ANCOVA  | SMD     | ANCOVA  | SMD      | ANCOVA  | SMD     | ANCOVA  |
| Panel A |         |         |         |         |          |         |         |         |
| ATT     | 0.188   | 0.177   | 0.240   | 0.248   | 0.050    | 0.055   | 0.135   | 0.135   |
|         | (0.032) | (0.026) | (0.015) | (0.016) | (0.028)  | (0.026) | (0.026) | (0.025) |
|         | [0.000] | [0.000] | [0.000] | [0.000] | [0.074]  | [0.033] | [0.000] | [0.000] |
|         | {0.001} | {0.001} | {0.001} | {0.001} | {0.023}  | {0.011} | {0.001} | {0.001} |
|         | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.025⟩  | ⟨0.010⟩ | ⟨0.000⟩ | ⟨0.001⟩ |
| Obs     | 430     | 430     | 430     | 430     | 430      | 430     | 430     | 430     |
| Control | 0.460   | 0.460   | 0.490   | 0.490   | 0.594    | 0.594   | 0.233   | 0.233   |
| mean    |         |         |         |         |          |         |         |         |
| Panel B |         |         |         |         |          |         |         |         |
| ATT     | 0.221   | 0.215   | 0.267   | 0.273   | 0.053    | 0.058   | 0.145   | 0.147   |
|         | (0.004) | (0.004) | (0.004) | (0.006) | (0.005)  | (0.006) | (0.005) | (0.005) |
|         | [0.000] | [0.000] | [0.000] | [0.000] | [0.000]  | [0.000] | [0.000] | [0.000] |
|         | {0.001} | {0.001} | {0.001} | {0.001} | {0.001}  | {0.001} | {0.001} | {0.001} |
|         | ⟨0.129⟩ | ⟨0.129⟩ | ⟨0.129⟩ | ⟨0.180⟩ | ⟨0.129⟩  | ⟨0.150⟩ | ⟨0.129⟩ | ⟨0.129⟩ |
| Obs     | 430     | 430     | 430     | 430     | 430      | 430     | 430     | 430     |
| Control | 0.460   | 0.460   | 0.490   | 0.490   | 0.594    | 0.594   | 0.233   | 0.233   |
| mean    |         |         |         |         |          |         |         |         |

Notes: ISFWC is a package combination of manure, mulch, and trenches. SMD is the Simple Mean Difference. ANCOVA is Analysis of Covariance. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), based on 2,000 draws, are in ⟨diamond brackets⟩. FDR denotes false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively.

Table 2.4 Effects of participation in audio-visual sessions on the adoption of soil-improving and water conservation measures

|              | Manure  |         | Mulch   |         | Trenches |         | ISFWC   |         |
|--------------|---------|---------|---------|---------|----------|---------|---------|---------|
|              | SMD     | ANCOVA  | SMD     | ANCOVA  | SMD      | ANCOVA  | SMD     | ANCOVA  |
| Panel A      |         |         |         |         |          |         |         |         |
| ATT1         | 0.206   | 0.194   | 0.263   | 0.270   | 0.055    | 0.060   | 0.148   | 0.148   |
|              | (0.033) | (0.027) | (0.017) | (0.017) | (0.031)  | (0.028) | (0.028) | (0.027) |
|              | [0.000] | [0.000] | [0.000] | [0.000] | [0.076]  | [0.034] | [0.000] | [0.000] |
|              | {0.001} | {0.001} | {0.001} | {0.001} | {0.015}  | {0.008} | {0.001} | {0.001} |
|              | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.025⟩  | ⟨0.012⟩ | ⟨0.000⟩ | ⟨0.000⟩ |
| Observations | 430     | 430     | 430     | 430     | 430      | 430     | 430     | 430     |
| Control mean | 0.460   | 0.460   | 0.490   | 0.490   | 0.594    | 0.594   | 0.233   | 0.233   |
| Panel B      |         |         |         |         |          |         |         |         |
| ATT 1        | 0.250   | 0.241   | 0.301   | 0.307   | 0.060    | 0.066   | 0.164   | 0.166   |
|              | (0.005) | (0.004) | (0.005) | (0.007) | (0.005)  | (0.006) | (0.005) | (0.005) |
|              | [0.000] | [0.000] | [0.000] | [0.000] | [0.000]  | [0.000] | [0.000] | [0.000] |
|              | {0.001} | {0.001} | {0.001} | {0.001} | {0.001}  | {0.001} | {0.001} | {0.001} |
|              | ⟨0.075⟩ | ⟨0.047⟩ | ⟨0.075⟩ | ⟨0.060⟩ | ⟨0.083⟩  | ⟨0.064⟩ | ⟨0.075⟩ | ⟨0.060⟩ |
| Observations | 430     | 430     | 430     | 430     | 430      | 430     | 430     | 430     |
| Control mean | 0.460   | 0.460   | 0.490   | 0.490   | 0.594    | 0.594   | 0.233   | 0.233   |

Notes: ISFWC is a package combination of manure, mulch, and trenches. SMD is the Simple Mean Difference. ANCOVA is Analysis of Covariance. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), based on 2,000 draws, are in ⟨diamond brackets⟩. FDR denotes false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively.

Table 2.5 Effects of participation in hands-on sessions on the adoption of soil-improving and water conservation measures

|              | Manure  |         | Mulch   |         | Trenches |         | ISFWC   |         |
|--------------|---------|---------|---------|---------|----------|---------|---------|---------|
|              | SMD     | ANCOVA  | SMD     | ANCOVA  | SMD      | ANCOVA  | SMD     | ANCOVA  |
| Panel A      |         |         |         |         |          |         |         |         |
| ATT 2        | 0.197   | 0.187   | 0.252   | 0.260   | 0.053    | 0.058   | 0.142   | 0.142   |
|              | (0.032) | (0.027) | (0.018) | (0.020) | (0.029)  | (0.026) | (0.026) | (0.025) |
|              | [0.000] | [0.000] | [0.000] | [0.000] | [0.069]  | [0.029] | [0.000] | [0.000] |
|              | {0.001} | {0.001} | {0.001} | {0.001} | {0.014}  | {0.008} | {0.001} | {0.001} |
|              | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.025⟩  | ⟨0.011⟩ | ⟨0.000⟩ | 0.000   |
| Observations | 430     | 430     | 430     | 430     | 430      | 430     | 430     | 430     |
| Control      | 0.460   | 0.460   | 0.490   | 0.490   | 0.594    | 0.594   | 0.233   | 0.233   |
| mean         |         |         |         |         |          |         |         |         |
| Panel B      |         |         |         |         |          |         |         |         |
| ATT 2        | 0.231   | 0.225   | 0.278   | 0.285   | 0.055    | 0.061   | 0.152   | 0.153   |
|              | (0.004) | (0.004) | (0.004) | (0.006) | (0.005)  | (0.006) | (0.005) | (0.005) |
|              | [0.000] | [0.000] | [0.000] | [0.000] | [0.000]  | [0.000] | [0.000] | [0.000] |
|              | {0.001} | {0.001} | {0.001} | {0.001} | {0.001}  | {0.001} | {0.001} | {0.001} |
|              | ⟨0.082⟩ | ⟨0.060⟩ | ⟨0.082⟩ | ⟨0.100⟩ | ⟨0.082⟩  | ⟨0.100⟩ | ⟨0.082⟩ | ⟨0.100⟩ |
| Observations | 430     | 430     | 430     | 430     | 430      | 430     | 430     | 430     |
| Control      | 0.460   | 0.460   | 0.490   | 0.490   | 0.594    | 0.594   | 0.233   | 0.233   |
| mean         |         |         |         |         |          |         |         |         |

Notes: ISFWC is a package combination of manure, mulch, and trenches. SMD is the Simple Mean Difference. ANCOVA is Analysis of Covariance. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), based on 2,000 draws, are in ⟨diamond brackets⟩. FDR denotes false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively.

Attendance of both audio-visual and hands-on sessions significantly influenced adoption of all the individual practices and the ISFWC package at the 5% level at worst, even after correcting for multiple hypothesis testing (Table 2.6). Participation in both kinds of sessions increased uptake of manure use by between 21-22 percentage points (Panel A) and between 25-26 percentage points (Panel B), compared to the control group exposed to only the audio channel. Furthermore, utilization of mulch increased by between 28 to 32 percentage points, whereas the establishment of water trenches increased

by 6-7 percentage points among farmers who took part in both kinds of sessions. Also, adoption of the ISFWC package increased by between 16 to 18 percentage points among these participants compared to the control group. Our results are consistent with Beaman et al. (2021) who found that the adoption of pit planting, a soil conservation practice was between 12.6-39.1% higher among the treated group depending on the dissemination channel.

Table 2.6 Effects of participation in both audio-visual and hands-on sessions on adoption of soil-improving and water conservation measures

|              | Manure  |         | Mulch   |         | Trenches |         | ISFWC   |         |
|--------------|---------|---------|---------|---------|----------|---------|---------|---------|
|              | SMD     | ANCOVA  | SMD     | ANCOVA  | SMD      | ANCOVA  | SMD     | ANCOVA  |
| Panel A      |         |         |         |         |          |         |         |         |
| ATT 3        | 0.217   | 0.206   | 0.277   | 0.284   | 0.058    | 0.063   | 0.156   | 0.156   |
|              | (0.034) | (0.028) | (0.020) | (0.022) | (0.032)  | (0.029) | (0.028) | (0.027) |
|              | [0.000] | [0.000] | [0.000] | [0.000] | [0.071]  | [0.031] | [0.000] | [0.000] |
|              | {0.001} | {0.001} | {0.001} | {0.001} | {0.014}  | {0.008} | {0.001} | {0.001} |
|              | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.000⟩ | ⟨0.028⟩  | ⟨0.009⟩ | ⟨0.001⟩ | ⟨0.000⟩ |
| Observations | 430     | 430     | 430     | 430     | 430      | 430     | 430     | 430     |
| Control mean | 0.460   | 0.460   | 0.490   | 0.490   | 0.594    | 0.594   | 0.233   | 0.233   |
| Panel B      |         |         |         |         |          |         |         |         |
| ATT 3        | 0.262   | 0.253   | 0.316   | 0.322   | 0.056    | 0.069   | 0.167   | 0.175   |
|              | (0.004) | (0.004) | (0.005) | (0.007) | (0.007)  | (0.007) | (0.006) | (0.006) |
|              | [0.000] | [0.000] | [0.000] | [0.000] | [0.000]  | [0.000] | [0.000] | [0.000] |
|              | {0.001} | {0.001} | {0.001} | {0.001} | {0.001}  | {0.001} | {0.001} | {0.001} |
|              | ⟨0.041⟩ | ⟨0.035⟩ | ⟨0.041⟩ | ⟨0.036⟩ | ⟨0.041⟩  | ⟨0.041⟩ | ⟨0.041⟩ | ⟨0.045⟩ |
| Observations | 430     | 430     | 430     | 430     | 430      | 430     | 430     | 430     |
| Control mean | 0.460   | 0.460   | 0.490   | 0.490   | 0.594    | 0.594   | 0.233   | 0.233   |

Notes: ISFWC is a package combination of manure, mulch, and trenches. SMD is the Simple Mean Difference. ANCOVA is Analysis of Covariance. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” [i.e., q-values] are in curly brackets while Randomisation-t p-values following Young (2019), based on 2,000 draws, are in ⟨diamond brackets⟩. FDR denotes false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively.

Overall, we observe higher adoption rates across all technologies among those who attended both audio-visual and hands-on sessions, followed by those who attended audio-visual sessions. These results are illustrated graphically in Figure 2.5 in the appendix.

### *2.5.3 Access to information, adoption of soil improving and water conservation measures and household welfare.*

The results in the previous section reveal a significant impact of information flow on the adoption of soil-improving and water conservation practices. Uptake of practices is a direct channel through which yields, and subsequently the marketed surplus and household incomes are likely to increase.

Table 2.7 reports the treatment effects of the intervention on these welfare outcomes. The campaign resulted in an increase in yields between 674 and 757 kg/acre among the treatment communities relative to the control. This corresponds to a 9.1%–10.2% increase in yield among the treated group. These gains are comparable to those observed among rice farmers in India, where productivity improved by 12% – 18% following the dissemination of information on sustainable rice intensification through video-based interventions (Baul et al., 2024). Increased yields are expected to result in a higher marketed surplus. The marketed surplus, computed as the proportion of the harvest sold, increased by between 11-15 percentage points (panel A) and 13-17 percentage points (panel B) in the treatment groups as a result of the intervention. The annual incomes of the households that were exposed to the campaign increased by between 1.1 -1.8 (panel A) and 1.2-2.4 million Uganda shillings (panel B), compared to those in the control group. Such increases in income are more than sufficient to cover the incremental costs of uptake of the practices as highlighted in Section 5.6. Furthermore, this effect of the campaign intervention on income is of economic significance since it translates into an 18.8% - 39.4% increment among the households in the treatment group compared to the control group.

Table 2.7 Impact of the extension-based campaign on farmers' welfare.

|              | Yield (ton/acre) |         | Marketed surplus (%) |         | Household income (Million UGX) |         |
|--------------|------------------|---------|----------------------|---------|--------------------------------|---------|
|              | SMD              | ANCOVA  | SMD                  | ANCOVA  | SMD                            | ANCOVA  |
| Panel A      |                  |         |                      |         |                                |         |
| ITT          | 0.757            | 0.674   | 0.109                | 0.150   | 1.136                          | 1.825   |
|              | (0.169)          | (0.171) | (0.011)              | (0.011) | (0.313)                        | (0.412) |
|              | [0.007]          | [0.011] | [0.000]              | [0.000] | [0.015]                        | [0.007] |
|              | {0.004}          | {0.005} | {0.001}              | {0.001} | {0.007}                        | {0.004} |
|              | ⟨0.005⟩          | ⟨0.010⟩ | ⟨0.000⟩              | ⟨0.001⟩ | ⟨0.011⟩                        | ⟨0.007⟩ |
| Observations | 430              | 430     | 430                  | 430     | 430                            | 430     |
| Control mean | 7.409            | 7.409   | 0.322                | 0.322   | 6.052                          | 6.052   |
| Panel B      |                  |         |                      |         |                                |         |
| ITT          | 0.754            | 0.690   | 0.133                | 0.167   | 1.216                          | 2.385   |
|              | (0.000)          | (0.020) | (0.001)              | (0.005) | (0.356)                        | (0.177) |
|              | [0.000]          | [0.000] | [0.000]              | [0.000] | [0.001]                        | [0.000] |
|              | {0.001}          | {0.001} | {0.001}              | {0.001} | {0.001}                        | {0.001} |
|              | ⟨0.000⟩          | ⟨0.000⟩ | ⟨0.000⟩              | ⟨0.000⟩ | ⟨0.024⟩                        | ⟨0.001⟩ |
| Observations | 430              | 430     | 430                  | 430     | 430                            | 430     |
| Control mean | 7.409            | 7.409   | 0.322                | 0.322   | 6.052                          | 6.052   |

Notes: 1 USD=3750 UGX (Uganda shillings). SMD is the Simple Mean Difference. ANCOVA is Analysis of Covariance. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected "p-values" {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), based on 2,000 draws, are in ⟨diamond brackets⟩. FDR denotes false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively. Marketed surplus=proportion of harvested bananas sold.

The ATT estimates are presented in Tables 2.8-2.11. Participation in any training session resulted in a significant increase in all the welfare outcomes (Table 2.8, Panel A). However, following covariate adjustment, these results do not survive randomization inference correction (Table 2.8, Panel B).

Table 2.8 Impact of participation in any training session on farmers' welfare.

|              | Yield (ton/acre) |         | Marketed surplus (%) |         | Household income (Million UGX) |         |
|--------------|------------------|---------|----------------------|---------|--------------------------------|---------|
|              | SMD              | ANCOVA  | SMD                  | ANCOVA  | SMD                            | ANCOVA  |
| Panel A      |                  |         |                      |         |                                |         |
| ATT          | 0.876            | 0.778   | 0.126                | 0.176   | 1.315                          | 2.121   |
|              | (0.176)          | (0.176) | (0.012)              | (0.011) | (0.324)                        | (0.428) |
|              | [0.000]          | [0.000] | [0.000]              | [0.000] | [0.000]                        | [0.000] |
|              | {0.001}          | {0.001} | {0.001}              | {0.001} | {0.001}                        | {0.001} |
|              | ⟨0.001⟩          | ⟨0.001⟩ | ⟨0.000⟩              | ⟨0.000⟩ | ⟨0.003⟩                        | ⟨0.003⟩ |
| Observations | 430              | 430     | 430                  | 430     | 430                            | 430     |
| Control mean | 7.409            | 7.409   | 0.322                | 0.322   | 6.052                          | 6.052   |
| Panel B      |                  |         |                      |         |                                |         |
| ATT          | 0.922            | 0.835   | 0.143                | 0.187   | 1.353                          | 2.829   |
|              | (0.091)          | (0.110) | (0.009)              | (0.007) | (0.320)                        | (0.368) |
|              | [0.000]          | [0.000] | [0.000]              | [0.000] | [0.000]                        | [0.000] |
|              | {0.001}          | {0.001} | {0.001}              | {0.001} | {0.001}                        | {0.001} |
|              | ⟨0.129⟩          | ⟨0.113⟩ | ⟨0.129⟩              | ⟨0.150⟩ | ⟨0.129⟩                        | ⟨0.451⟩ |
| Observations | 430              | 430     | 430                  | 430     | 430                            | 430     |
| Control mean | 7.409            | 7.409   | 0.322                | 0.322   | 6.052                          | 6.052   |

Notes: 1 USD=3750 UGX (Uganda shillings). SMD is the Simple Mean Difference. ANCOVA is Analysis of Covariance. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected "p-values" {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), based on 2,000 draws, are in ⟨diamond brackets⟩. FDR denotes false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively. Marketed surplus=proportion of harvested bananas sold.

Without covariate adjustment, the increase in yield resulting from attending either audio-visual or hands-on sessions was significant at the 1% level, even after controlling for multiple hypothesis testing (Tables 2.9 and 2.10, Panel A). However, with covariate adjustment, the increment is only significant at the 10% level, after RI correction (Panel B).

Similar to the market surplus estimates, the effect of attending either audio-visual or practical sessions significantly increased household incomes at the 1% level without covariate adjustment, even after

controlling for FDR and RI correction (Panel A, Tables 2.9-2.10). With covariate adjustment, this effect is only significant at the 10% level after RI correction, except in the ANCOVA estimation of hands-on sessions where no significant effect is observed (RI p-value=0.100).

Table 2.9 Impact of participation in audio-visual sessions on farmers' welfare.

|              | Yield (ton/acre) |         | Marketed surplus (%) |         | Household income (Million UGX) |         |
|--------------|------------------|---------|----------------------|---------|--------------------------------|---------|
|              | SMD              | ANCOVA  | SMD                  | ANCOVA  | SMD                            | ANCOVA  |
| Panel A      |                  |         |                      |         |                                |         |
| ATT 1        | 0.960            | 0.853   | 0.138                | 0.195   | 1.441                          | 2.313   |
|              | (0.192)          | (0.192) | (0.011)              | (0.013) | (0.356)                        | (0.466) |
|              | [0.000]          | [0.000] | [0.000]              | [0.000] | [0.000]                        | [0.000] |
|              | {0.001}          | {0.001} | {0.001}              | {0.001} | {0.001}                        | {0.001} |
|              | ⟨0.000⟩          | ⟨0.001⟩ | ⟨0.000⟩              | ⟨0.000⟩ | ⟨0.001⟩                        | ⟨0.001⟩ |
| Observations | 430              | 430     | 430                  | 430     | 430                            | 430     |
| Control mean | 7.409            | 7.409   | 0.322                | 0.322   | 6.052                          | 6.052   |
| Panel B      |                  |         |                      |         |                                |         |
| ATT 1        | 1.041            | 0.944   | 0.161                | 0.213   | 1.483                          | 3.166   |
|              | (0.103)          | (0.122) | (0.010)              | (0.009) | (0.343)                        | (0.400) |
|              | [0.000]          | [0.000] | [0.000]              | [0.000] | [0.000]                        | [0.000] |
|              | {0.001}          | {0.001} | {0.001}              | {0.001} | {0.001}                        | {0.001} |
|              | ⟨0.075⟩          | ⟨0.075⟩ | ⟨0.083⟩              | ⟨0.059⟩ | ⟨0.066⟩                        | ⟨0.082⟩ |
| Observations | 430              | 430     | 430                  | 430     | 430                            | 430     |
| Control mean | 7.409            | 7.409   | 0.322                | 0.322   | 6.052                          | 6.052   |

Notes: 1 USD=3750 UGX (Uganda shillings). SMD is the Simple Mean Difference. ANCOVA is Analysis of Covariance. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected "p-values" {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), based on 2,000 draws, are in ⟨diamond brackets⟩. FDR denotes false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively. Marketed surplus=proportion of harvested bananas sold.

Table 2.10 Impact of participation in hands-on sessions on farmers' welfare.

|              | Yield (ton/acre) |         | Marketed surplus (%) |         | Household income (Million UGX) |         |
|--------------|------------------|---------|----------------------|---------|--------------------------------|---------|
|              | SMD              | ANCOVA  | SMD                  | ANCOVA  | SMD                            | ANCOVA  |
| Panel A      |                  |         |                      |         |                                |         |
| ATT 2        | 0.920            | 0.816   | 0.132                | 0.185   | 1.381                          | 2.220   |
|              | (0.186)          | (0.187) | (0.013)              | (0.012) | (0.334)                        | (0.439) |
|              | [0.000]          | [0.000] | [0.000]              | [0.000] | [0.000]                        | [0.000] |
|              | {0.001}          | {0.001} | {0.001}              | {0.001} | {0.001}                        | {0.001} |
|              | ⟨0.001⟩          | ⟨0.002⟩ | ⟨0.000⟩              | ⟨0.000⟩ | ⟨0.001⟩                        | ⟨0.002⟩ |
| Observations | 430              | 430     | 430                  | 430     | 430                            | 430     |
| Control mean | 7.409            | 7.409   | 0.322                | 0.322   | 6.052                          | 6.052   |
| Panel B      |                  |         |                      |         |                                |         |
| ATT 2        | 0.962            | 0.870   | 0.149                | 0.195   | 1.427                          | 2.967   |
|              | (0.096)          | (0.115) | (0.009)              | (0.007) | (0.332)                        | (0.384) |
|              | [0.000]          | [0.000] | [0.000]              | [0.000] | [0.000]                        | [0.000] |
|              | {0.001}          | {0.001} | {0.001}              | {0.001} | {0.001}                        | {0.001} |
|              | ⟨0.082⟩          | ⟨0.075⟩ | ⟨0.082⟩              | ⟨0.090⟩ | ⟨0.096⟩                        | ⟨0.100⟩ |
| Observations | 430              | 430     | 430                  | 430     | 430                            | 430     |
| Control mean | 7.409            | 7.409   | 0.322                | 0.322   | 6.052                          | 6.052   |

Notes: 1 USD=3750 UGX (Uganda shillings). SMD is the Simple Mean Difference. ANCOVA is Analysis of Covariance. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), based on 2,000 draws, are in ⟨diamond brackets⟩. FDR denotes false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively. Marketed surplus=proportion of harvested bananas sold.

The estimates in Table 2.11 show that participation in both sessions significantly increased yields by between 898-1013 kg/acre (Panel A) and 1067-1172 kg/acre (Panel B) at the 5% level with RI correction. As expected, the yield increments are higher among the farming households that attended the lecture trainings/watched the video shows and participated in the demos/farmer field days than those who only listened to the radio talk shows. The average yield increase was between 12.1-13.7% (panel A) and 14.4-15.8% (panel B). Intuitively, attendance of both kinds of sessions enabled farmers to not only hear but also visualize and understand the technicalities of the practices and the potential benefits resulting in increased adoption and higher yields (Baul et al., 2024; Van Campenhout et al., 2021).

Table 2.11 Impact of participation in audio-visual and hands-on sessions on farmers' welfare.

|              | Yield (ton/acre) |         | Marketed surplus (%) |         | Household income (Million UGX) |         |
|--------------|------------------|---------|----------------------|---------|--------------------------------|---------|
|              | SMD              | ANCOVA  | SMD                  | ANCOVA  | SMD                            | ANCOVA  |
| Panel A      |                  |         |                      |         |                                |         |
| ATT 3        | 1.013            | 0.898   | 0.146                | 0.205   | 1.521                          | 2.432   |
|              | (0.204)          | (0.206) | (0.013)              | (0.015) | (0.369)                        | (0.478) |
|              | [0.000]          | [0.000] | [0.000]              | [0.000] | [0.000]                        | [0.000] |
|              | {0.001}          | {0.001} | {0.001}              | {0.001} | {0.001}                        | {0.001} |
|              | ⟨0.001⟩          | ⟨0.001⟩ | ⟨0.000⟩              | ⟨0.000⟩ | ⟨0.001⟩                        | ⟨0.001⟩ |
| Observations | 430              | 430     | 430                  | 430     | 430                            | 430     |
| Control mean | 7.409            | 7.409   | 0.322                | 0.322   | 6.052                          | 6.052   |
| Panel B      |                  |         |                      |         |                                |         |
| ATT 3        | 1.172            | 1.067   | 0.169                | 0.224   | 1.573                          | 3.340   |
|              | (0.107)          | (0.121) | (0.010)              | (0.009) | (0.356)                        | (0.419) |
|              | [0.000]          | [0.000] | [0.000]              | [0.000] | [0.000]                        | [0.000] |
|              | {0.001}          | {0.001} | {0.001}              | {0.001} | {0.001}                        | {0.001} |
|              | ⟨0.041⟩          | ⟨0.041⟩ | ⟨0.041⟩              | ⟨0.033⟩ | ⟨0.041⟩                        | ⟨0.041⟩ |
| Observations | 430              | 430     | 430                  | 430     | 430                            | 430     |
| Control mean | 7.409            | 7.409   | 0.322                | 0.322   | 6.052                          | 6.052   |

Notes: 1 USD=3750 UGX (Uganda shillings). SMD is the Simple Mean Difference. ANCOVA is Analysis of Covariance. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected "p-values" {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), based on 2,000 draws, are in ⟨diamond brackets⟩. FDR denotes false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively. Marketed surplus=proportion of harvested bananas sold.

Participation in both sessions significantly increased the marketed surplus by between 15-21% (panel A) and 17-22% (panel B) as shown in Table 2.11. Attendance of both audio-visual and practical sessions significantly increased household incomes at the 5% level at worst, after controlling for FDR and RI (Table 2.11). The increment was between 1.5-2.4 million shillings (Panel A) and 1.6-3.3 million shillings (panel B) among the participating households. Overall, the highest impact on household welfare is observed when farmers participate in both audio-visual and practical sessions.

#### 2.5.4 Local Average Treatment Effect (LATE) for the practices

To the extent that some farmers may participate in the trainings, but not adopt the conservation practices, we also analyze the effect of the adoption of the practices on household welfare by estimating the Local Average Treatment Effect (LATE) for the practices. The estimates for the three outcomes are summarized in Table 2.12. For brevity, we only show the results without covariate adjustment. The results indicate that the uptake of manure, mulch, and the ISFWC package had positive and statistically significant effects on household welfare. The highest impact occurs with the uptake of the package which increases yield by 6 tons/acre, more than doubles the marketed surplus, and increases household income by over eleven million Uganda shillings per annum<sup>5</sup>. The adoption of trenches also positively influences household welfare, although the coefficients are not statistically significant.

In particular, our findings indicate that the increments in yield which ranges between 3.3. - 6.5 tons per acre and household income ranging between 5.5 – 15.6 million Uganda shillings (US \$1,467 - 4,160) per annum, resulting from adoption of the individual conservation measures and the package are more than enough to offset the costs of their implementation that are highlighted in Section 2.6.1.

Table 2.12 Impact of adoption of soil-improving and water conservation practices on farmers' welfare

|               | Yield (ton/acre) |         | Marketed surplus (%) |         | Household income (Million UGX) |         |
|---------------|------------------|---------|----------------------|---------|--------------------------------|---------|
|               | SMD              | ANCOVA  | SMD                  | ANCOVA  | SMD                            | ANCOVA  |
| <b>Manure</b> |                  |         |                      |         |                                |         |
| LATE          | 4.664            | 4.224   | 0.671                | 0.879   | 7.002                          | 11.182  |
|               | (1.471)          | (1.400) | (0.108)              | (0.203) | (2.217)                        | (2.614) |
|               | [0.002]          | [0.003] | [0.000]              | [0.000] | [0.002]                        | [0.000] |
|               | {0.002}          | {0.002} | {0.001}              | {0.001} | {0.002}                        | {0.001} |
|               | ⟨0.003⟩          | ⟨0.003⟩ | ⟨0.001⟩              | ⟨0.001⟩ | ⟨0.003⟩                        | ⟨0.002⟩ |
| <b>Mulch</b>  |                  |         |                      |         |                                |         |
| LATE          | 3.655            | 3.322   | 0.526                | 0.649   | 5.486                          | 8.414   |

<sup>5</sup> While we expect high income effects among the compliers, particularly those that adopted the package, we interpret these results with caution because household income is not an immediate outcome and it is measured as a composite of multiple sources, including on-farm and off-farm.

|                 |          |          |         |         |          |          |
|-----------------|----------|----------|---------|---------|----------|----------|
|                 | (0.896)  | (0.885)  | (0.056) | (0.075) | (1.548)  | (1.947)  |
|                 | [0.000]  | [0.000]  | [0.000] | [0.000] | [0.000]  | [0.000]  |
|                 | {0.001}  | {0.001}  | {0.001} | {0.001} | {0.001}  | {0.001}  |
|                 | ⟨0.002⟩  | ⟨0.002⟩  | ⟨0.001⟩ | ⟨0.001⟩ | ⟨0.003⟩  | ⟨0.001⟩  |
| <b>Trenches</b> |          |          |         |         |          |          |
| LATE            | 17.388   | 15.624   | 2.503   | 3.376   | 26.104   | 47.606   |
|                 | (11.961) | (11.344) | (1.551) | (1.922) | (16.597) | (29.915) |
|                 | [0.146]  | [0.168]  | [0.107] | [0.079] | [0.116]  | [0.112]  |
|                 | {0.038}  | {0.044}  | {0.033} | {0.025} | {0.033}  | {0.032}  |
|                 | ⟨0.051⟩  | ⟨0.063⟩  | ⟨0.033⟩ | ⟨0.025⟩ | ⟨0.034⟩  | ⟨0.031⟩  |
| <b>ISFWC</b>    |          |          |         |         |          |          |
| LATE            | 6.486    | 5.981    | 0.934   | 1.179   | 9.738    | 15.611   |
|                 | (2.231)  | (2.177)  | (0.207) | (0.251) | (3.140)  | (3.881)  |
|                 | [0.004]  | [0.006]  | [0.000] | [0.000] | [0.002]  | [0.000]  |
|                 | {0.004}  | {0.004}  | {0.001} | {0.001} | {0.002}  | {0.001}  |
|                 | ⟨0.005⟩  | ⟨0.007⟩  | ⟨0.001⟩ | ⟨0.001⟩ | ⟨0.003⟩  | ⟨0.002⟩  |
| Control mean    | 7.409    | 7.409    | 0.322   | 0.322   | 6.052    | 6.052    |
| Observations    | 430      | 430      | 430     | 430     | 430      | 430      |

Notes: 1 USD=3750 UGX (Uganda shillings). SMD is the Simple Mean Difference. ANCOVA is Analysis of Covariance. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), based on 2,000 draws, are in ⟨diamond brackets⟩. FDR denotes false discovery rate. The estimates shown are without covariate adjustment. Marketed surplus=proportion of harvested bananas sold.

### 2.5.5 Treatment heterogeneity

Treatment effects logically vary across individuals or groups because people differ in their characteristics, constraints, and contexts that influence how they respond to interventions. Measuring heterogeneous treatment effects is meaningful because it reveals for whom and under what conditions an intervention is most effective. This information helps avoid one-size-fits-all policy recommendations and instead supports more targeted, efficient, and equitable interventions. By understanding these

differences, policymakers and practitioners can better allocate limited resources, prioritizing support for subgroups most likely to benefit, thereby enhancing both the cost-effectiveness and the impact of development programs.

The heterogeneous impacts of the campaign-based extension approach by pre-treatment covariates for each outcome are presented in Table 2.13. We tested for heterogeneity across all the control variables, but we only report statistically significant results for brevity.

The study identified several heterogeneous treatment effects across key outcomes, with variations largely shaped by resource access, ownership of media devices, and household characteristics. These findings have important implications for targeting strategies and policy design.

Table 2.13 Heterogeneous treatment effects conditional on the pre-treatment characteristics

|   | (1)                 | (2)                | (3)                 | (4)                | (5)                 |
|---|---------------------|--------------------|---------------------|--------------------|---------------------|
| Variable                                    | Manure              | Mulch              | ISFWC               | Yield              | Marketed surplus    |
| Not credit constrained                      | 0.270***<br>(0.100) |                    |                     |                    | 0.206***<br>(0.059) |
| Education                                   | 0.027**<br>(0.013)  |                    |                     |                    |                     |
| Own television                              |                     | 0.256**<br>(0.124) |                     |                    |                     |
| Farming is household head's main occupation |                     |                    | -0.302**<br>(0.122) |                    |                     |
| Total value of assets (log)                 |                     |                    |                     | 0.604**<br>(0.255) |                     |
| Own radio                                   |                     |                    |                     |                    | 0.180**<br>(0.077)  |
| Observations                                | 430                 | 430                | 430                 | 430                | 430                 |

Note: The results are generated through the generalized random forest technique using the *grf* package in R. Standard errors are in parentheses. \*\*\*p < 0.01, \*\*p < 0.05.

Access to credit emerged as a significant driver of manure adoption and market participation. Specifically, the treatment had a positive and statistically significant impact on manure adoption and marketed surplus among households that were not credit-constrained. This is intuitive, since manure is costly, credit access allows households to purchase it. Additionally, credit enables liquidity smoothing,

whereby households can borrow money to meet immediate consumption needs, and reserve part of their produce for sale in the market. These findings suggest that targeting non-credit-constrained households, or coupling interventions with credit programs, could enhance manure uptake and improve commercialization outcomes. Similarly, asset-rich households—measured by the value of household assets—benefited more from the information campaign in terms of yield gains. This indicates that wealthier households may be better positioned to respond to agronomic advice, likely due to their superior access to complementary inputs and risk-buffering capacity.

Ownership of communication devices was also associated with differential impacts. Households that owned a television experienced significantly higher mulch adoption, while those with a radio showed greater increases in marketed surplus. These devices were key dissemination channels during the campaign, reinforcing the importance of media access in extension delivery. This highlights the potential of leveraging existing household infrastructure for scaling information campaigns, especially where physical extension outreach is limited.

The adoption of manure was higher among households headed by more educated individuals. This suggests that education may facilitate better comprehension or greater responsiveness to agronomic information. However, the lack of significance of the education attribute regarding the other practices is likely due to the design of the campaign, which was tailored to accommodate low-literacy audiences. Sessions were delivered in local languages with practical demonstrations and extensive use of visual aids, and they were interactive with question-and-answer segments. These methods have been shown to enhance learning regardless of education level (Van Campenhout et al., 2021). This suggests that carefully designed communication strategies can mitigate disparities due to low formal education.

A negative differential impact was observed in the uptake of the full suite of soil-improving and water conservation (ISFWC) practices among households whose heads primarily engage in farming. Though counterintuitive, this finding likely reflects multiple, overlapping constraints typical of farm-dependent households, including limited liquidity, seasonal labour shortages, and input scarcity. These constraints may hinder their ability to adopt the full package simultaneously. Accordingly, the study recommends a phased or incremental approach to adoption, encouraging gradual integration of practices over time.

No statistically significant heterogeneous treatment effects were found for the adoption of trenches or household income outcome estimations.

#### *2.5.6 Robustness of results*

We subjected our results to two robustness checks. First, as mentioned earlier, we assessed whether our results are robust to adjusting for multiple hypothesis testing and randomization inference across all the outcome domains considered in the paper and find that our results are robust to this concern. Second, we estimated difference-in-differences (DID) models for all the outcomes in the study. These are presented in the appendix (Tables 2.7A-2.11A). The results are generally similar to those shown in Tables 2.2-2.11, but predictably, they are estimated with less precision. Empirical evidence shows that in instances where there is only one baseline and follow-up survey, and the correlation of the outcomes in the two time periods is less than 0.5, ANCOVA has more power and generates more precise results than the DID (McKenzie, 2012). In line with this, out of all the DID estimates, relatively consistent results were observed for the Trenches and the marketed surplus outcomes. This is expected because these are the only outcomes in our study whose autocorrelations are above 0.5 though by very small magnitudes, as shown in Table 2.2A in the appendix.

We expect that accounting for environmental externalities may slightly influence the results but not significantly. Studies show that following the recommended guidelines in applying mulch, manure, and digging trenches gives rise to more environmental benefits than externalities (Kihara et al., 2022; Ngetich et al., 2014; Van Asten et al., 2011).

## **2.6 Cost-effectiveness of the practices and the intervention**

### *2.6.1 Cost-effectiveness of the practices*

The conservation practices we recommended—manure application, mulching, and trench establishment—are highly cost-effective. Manure use is most intensive during the establishment of a new plantation, requiring two 9kg basins per hole. For rehabilitation, which was the focus since the plantations were already established, the requirement reduces to approximately one basin per mat or stool annually, costing roughly a quarter of the price of one banana bunch. With proper management,

each mat/stool yields at least three bunches annually, making manure application economically viable. Mulching, primarily using dry banana leaves and pseudostems, partially replaces lost nutrients, but we recommend supplementing with external mulch like maize stover or elephant grass. These residues are often freely available, with farmers investing only in cutting, transporting, and applying them. This process typically costs 80,000–120,000 UGX (US \$23–32) per acre per year, equivalent to the value of 8–12 banana bunches. Moreover, well-mulched plantations suppress weeds, significantly reducing labour costs. Trench establishment, though labour-intensive, requires about three person-days per acre, costing around 90,000 UGX (US \$24) per acre. Maintenance, mainly involving weed removal from trenches, is straightforward and low-cost. Farmers generate between 4–12 million UGX (US \$1,067–3,200) per acre annually, depending on bunch sizes and market conditions, underscoring the cost-effectiveness of adopting these practices. We also emphasized the adoption of technologies in a stepwise/ phased manner based on the farmers' resource outlay to ease uptake.

#### *2.6.2 Cost-effectiveness of the campaign intervention*

Conducting a comprehensive cost-effectiveness analysis of any intervention is crucial and it depends on detailed, high-quality cost data. Since we do not have detailed data, we rely on aggregate cost estimates and credible assumptions for our analysis. Our campaign disseminated soil and water conservation technologies through multiple channels, achieving significant outreach. We could not explicitly determine the exact number of farmers reached through each channel partly because farmers are generally hesitant to register attendance<sup>6</sup> while radio listenership cannot be determined with certainty. Hence, we base our analysis on conservative estimates. The radio campaign cost about \$25,000 and 25,525 farmers from 56 districts responded to radio poll questions, indicating widespread listenership since not every listener responded. Considering only the respondents to the poll questions translates to a cost of \$0.98 ( $=25,000/25,525$ ) per farmer.

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<sup>6</sup> Farmers are often unwilling to register their attendance unless they receive something tangible, such as cash, transport refund, or foodstuffs. They believe that organizers might exploit their signatures for financial gain if they register without receiving a direct benefit. This mindset, common in rural Uganda, stems from experiences at political rallies.

The audio-visual channels comprised the video and lecture sessions. A consultant was hired to produce the drama film based on a script developed by the project team. Farmers selected from the local community in the treatment site comprised the cast. The drama was recorded on DVD. The film production cost was approximately \$12,000 and the dissemination cost amounted to \$1,500. The video screenings attracted 2,439 adults, thus the cost per farmer is \$5.54 ( $=13,500/2,439$ ). Before conducting the lecture sessions, thirty scaling agents (10 from each treatment site) including government and NGO extension workers and the three site coordinators attended the Training of Trainers (TOT)<sup>7</sup>. The total cost for the 3-day TOT was approximately \$3,000. Each agent trains at least 30 farmers per parish and operates in at least 5 parishes. Altogether, these extension workers trained about 4,950 farmers. The daily wage rate for extension officers is about \$20 per day, and they spend three days in each parish training for about 2 hours, thus the cost of training is \$9,900 ( $=20*5*3*33$ ). This amounts to a rate of \$2.61 ( $=(9,900+3,000)/4,950$ ) per farmer trained.

The farmer field days and the demonstration trials constitute the hands-on approaches. The recorded attendance at field days was 2,756 adult participants across three treatment sites, though the actual number was higher due to unregistered attendees<sup>8</sup>. The costs of organizing farmer field days include hire charges for tents, chairs, and a public address system, providing a meal for all participants, and supplying inputs for the demonstrations. Altogether, this is approximately \$2,500. Two field days were conducted per treatment site, hence the total cost for the three sites is \$15,000. This yields a cost of \$5.44 ( $=15,000/2,756$ ) per field day participant. The campaign established 40 demonstration trials in total. The costs involved include farm inputs, such as mulch and manure, wages for three hired labourers who work with the host and farmers, and transport costs for two research team members. This is approximately \$62 per demonstration plot. Overall, the 40 plots cost \$2,480 to establish. The demonstration sites registered 683 visitors, though this is underestimated, as hosts occasionally forgot to record visitors. The estimated amount spent per farmer trained is \$3.63 ( $=2,480/683$ ).

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<sup>7</sup> The campaign facilitated the TOT for these extension workers in the treatment districts and provided them with training materials to use in their work with farmers. Only the three site coordinators were directly supported further by the project to conduct farmer training sessions.

<sup>8</sup> We hired 500 chairs for the farmers on each field day, but these were all occupied with several other farmers sitting on the ground.

As expected, the audio channel had the highest coverage and lowest cost per farmer, but the costs per farmer for the other channels were also relatively low, ranging from \$2.60 to \$5.54. Our findings indicate that audio-visual, hands-on approaches and their combination had a greater impact on the adoption of practices, yields, sales, and household income. In value terms, yields increased by 17-21%, 17-20%, and 18-24% for the audio-visual, hands-on, and combined approaches, respectively, compared to the audio channel. Additionally, household income increased by \$384-845 for those who accessed information through audio-visual channels, \$368-792 for those who participated in hands-on training, and \$405-891 for farmers who used both channels relative to the radio. Considering these welfare improvements alongside the costs of adoption and intervention, it is evident that the campaign was cost-effective.

## **2.7 Conclusion**

Low crop yields in Sub-Saharan Africa are attributed to the effects of climate change, limited adoption of improved agricultural technologies, and impediments in information flow. Literature is replete with information on how improved extension services enhance the uptake of improved technologies and facilitate higher yields for smallholder farming households in Sub-Saharan Africa. However, most of these studies do not employ multiple information dissemination channels, yet farmers have varying access to, and preferences of information sources. In this study, we employed an extension-based campaign that used multiple communication channels to disseminate agricultural information to farmers in Uganda, through a randomized controlled trial. We compare the impact of utilizing audio-visual and hands-on approaches relative to audio means of communication in disseminating information pertinent to soil-improving and water conservation practices, including manure, mulch, and trenches. In Sub-Saharan Africa, where most livelihoods depend on rainfed agriculture characterized by continuous cropping without nutrient replenishment, declining soil fertility, climate change effects such as drought, and low crop productivity, employing conservation measures examined in this study helps mitigate these effects through increasing soil nutrient stocks, water infiltration, and enhancing nutrient and water use efficiency (Abdulai et al., 2011). Thus, as our findings show, the adoption of soil-improving and water conservation practices can contribute to an improvement in agricultural productivity and farmers'

welfare and promote environmental sustainability, which are crucial to achieving food security and poverty alleviation goals in Sub-Saharan African countries.

The campaign-based extension approach resulted in a significant increase in the adoption of manure, mulch, trenches, and the three practices combined. The intervention also significantly increased household welfare, measured by yields, marketed surplus, and household incomes. Our findings further show positive and statistically significant effects of actual participation in both audio-visual and hands-on sessions on the adoption of the practices and the welfare outcomes as opposed to only listening to the radio program. The farmers in our RCT must have benefited from the synergistic effects of a combination of these interventions during the campaign, resulting in increased technology uptake, as well as better welfare outcomes unlike those who were only exposed to audio messages (Van Campenhout et al., 2021).

Our findings provide valuable lessons for policymakers and practitioners involved in information dissemination, on the adoption of soil-improving and water conservation measures. The use of various communication channels and harnessing the ubiquity of mass media in extension systems facilitates the mobilization of larger numbers of farmers and enables the transmission of information to wider audiences. Therefore, policies that foster augmenting extension and advisory services with information communication technologies will have far-reaching effects, especially in creating awareness. Furthermore, providing farmers with intricate details regarding the approach, attributes, costs, and benefits of each conservation technique intrigues them to adopt. Policies that promote capacity building of extension staff and the development of reference materials such as visual aids and training manuals highlighting the technicalities and benefits of technologies, will facilitate the delivery of a uniform message and this is vital not only for novel technologies, but also existing soil-improving and water conservation measures which farmers may not be implementing partly due to myths, preconceived ideas, or insufficient knowledge. Utilizing visual aids such as posters that help to illustrate the techniques taught, as well as audio-visuels in conveying the message facilitates a clearer understanding of the practices and is likely to enhance adoption as these have the potential to influence changes in attitude and behavior (Chong & La Ferrara, 2009; Van Campenhout et al., 2021) as opposed to relying solely on

audio radio programs. Relaying the messages in the local dialects customized to address localized information needs and contexts and involving farmers as role models, especially in the drama and radio shows, helps to convey information even to those with low literacy levels, subsequently facilitating adoption (Abate et al., 2023). Disseminating information through audio-visual and hands-on approaches proved more effective than using audio alone, as the combination enhances comprehension through visual demonstrations, reinforces learning via direct engagement, and helps overcome literacy barriers. In addition to the positive and significant impacts of the campaign on adoption, yield, sales, and income, we also provide evidence that the initiative was cost-effective. Given our experimental design, we were unable to isolate the impact of each communication channel independently or the additive benefits of combining different channels. Future experimental research could address this limitation by implementing a randomized controlled trial with multiple treatment arms. These arms should include groups exposed to each communication channel independently, as well as groups receiving combinations of channels, to allow for a rigorous assessment of both standalone and synergistic effects.

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## Appendix

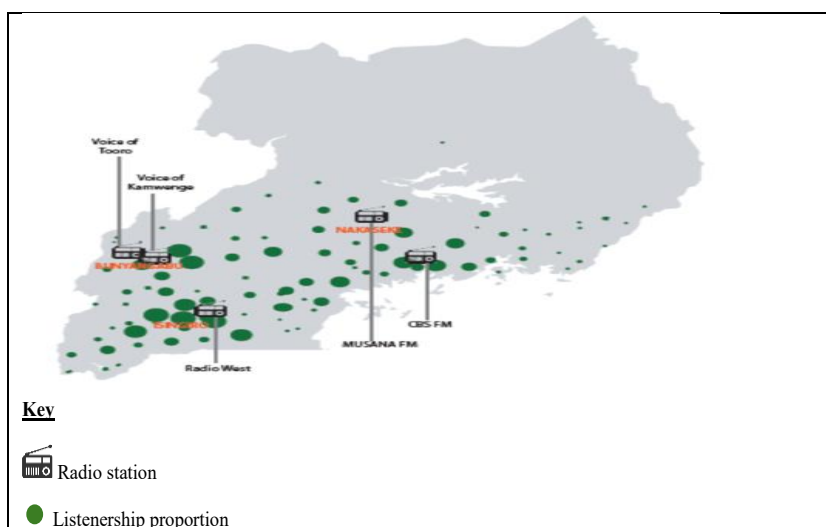


Figure 2.4: Map of Uganda showing the radio program listenership coverage based on the responses to the poll questions. Those in orange are the treatment sites.

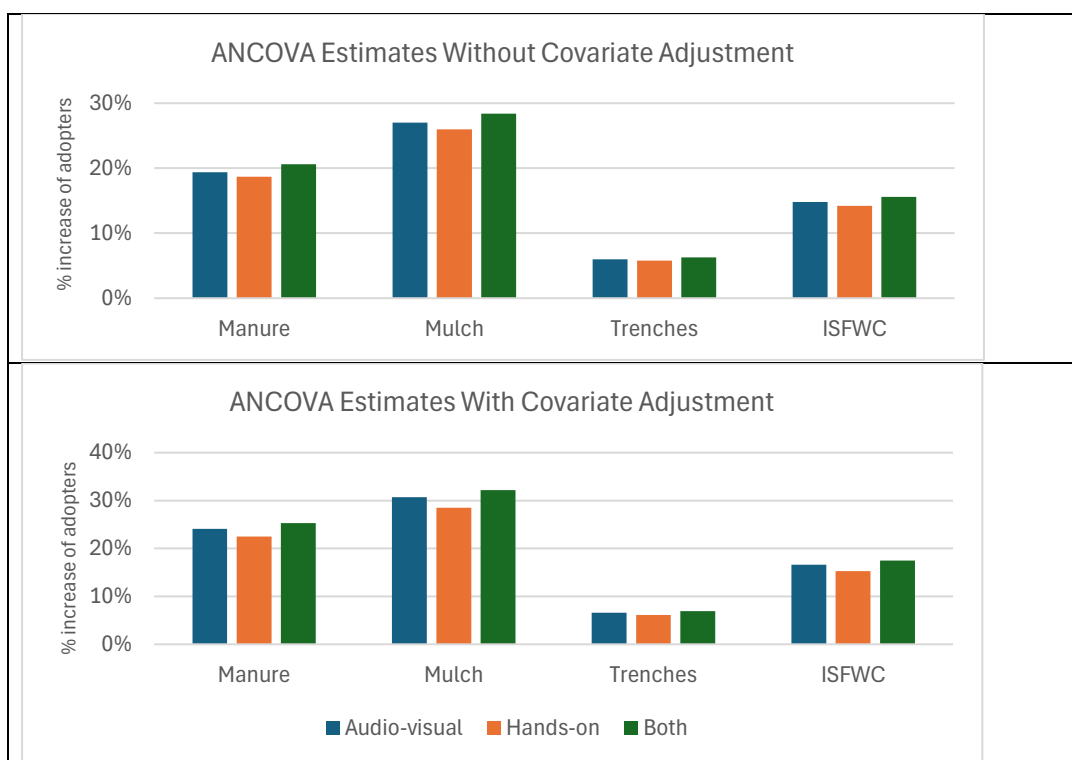


Figure 2.5: Graphical illustration of the ATT effects of participation in the audio-visual, hands-on and in both types of sessions.

Table 2.1A Attrition correlates

| Variable                              | Coefficient | Standard error |
|---------------------------------------|-------------|----------------|
| Treatment                             | -0.042      | 0.045          |
| Household size                        | -0.004      | 0.008          |
| Gender of household head (1=Male)     | 0.004       | 0.017          |
| Age of household head (years)         | -0.002      | 0.001          |
| Education of household head (years)   | -0.006      | 0.005          |
| Total land owned (acres)              | 0.003       | 0.003          |
| Banana plantation (acres)             | 0.005       | 0.009          |
| Household head is a farmer (1=Yes)    | -0.030      | 0.028          |
| Household owns a motorcycle (1=Yes)   | 0.042       | 0.040          |
| Household owns a bicycle (1=Yes)      | 0.029       | 0.049          |
| Household owns a phone (1=Yes)        | 0.063       | 0.035          |
| Household owns a radio (1=Yes)        | 0.017       | 0.026          |
| Household owns a TV (1=Yes)           | -0.039      | 0.048          |
| Log of total value of assets          | -0.007      | 0.013          |
| Tropical Livestock Units              | 0.006**     | 0.002          |
| Credit access-not constrained (1=Yes) | -0.025      | 0.037          |
| Belong to a farmer group (1=Yes)      | 0.018       | 0.025          |
| Constant                              | 0.262       | 0.134          |
| Observations                          | 471         |                |
| R-squared                             | 0.060       |                |

Notes: Outcome variable equals one if household attrited, zero otherwise. Results are estimated using a linear probability model. Standard errors adjusted for clustering at subcounty level are in parentheses. \*p<.10; \*\*p<.05; \*\*\*p<.01. F statistic on joint significance of treatment covariates is 0.86 with a p-value of 0.395.

Table 2.2A Autocorrelations of the outcome variables

| Outcome variables | $\rho$ |
|-------------------|--------|
| Manure adoption   | 0.253  |
| Mulch adoption    | 0.101  |
| Trenches adoption | 0.522  |
| ISFWC adoption    | 0.057  |
| Yield             | 0.133  |
| Marketed surplus  | 0.514  |
| Household income  | 0.485  |

Note: Tetrachoric correlations were used for the binary variables

Table 2.3A ANCOVA baseline outcome coefficients

| Model   | Manure              | Mulch                | Trenches            | ISFWC            | Yield               | Marketed surplus    | Household income    |
|---------|---------------------|----------------------|---------------------|------------------|---------------------|---------------------|---------------------|
| Panel A |                     |                      |                     |                  |                     |                     |                     |
| ITT     | 0.191**<br>(0.062)  | -0.078*<br>(0.032)   | 0.286***<br>(0.033) | 0.040<br>(0.060) | 0.131*<br>(0.053)   | 0.487***<br>(0.089) | 0.408**<br>(0.121)  |
| ATT     | 0.191***<br>(0.054) | -0.058<br>(0.036)    | 0.288***<br>(0.030) | 0.049<br>(0.055) | 0.134**<br>(0.054)  | 0.507***<br>(0.072) | 0.412***<br>(0.111) |
| ATT 1   | 0.189***<br>(0.055) | -0.047<br>(0.031)    | 0.291***<br>(0.031) | 0.060<br>(0.057) | 0.135***<br>(0.051) | 0.523***<br>(0.072) | 0.407***<br>(0.109) |
| ATT 2   | 0.185***<br>(0.052) | -0.054<br>(0.039)    | 0.287***<br>(0.030) | 0.047<br>(0.055) | 0.136**<br>(0.054)  | 0.505***<br>(0.070) | 0.409***<br>(0.110) |
| ATT 3   | 0.182***<br>(0.054) | -0.042<br>(0.034)    | 0.291***<br>(0.031) | 0.059<br>(0.057) | 0.137***<br>(0.050) | 0.523***<br>(0.070) | 0.403***<br>(0.108) |
| Panel B |                     |                      |                     |                  |                     |                     |                     |
| ITT     | 0.175**<br>(0.074)  | -0.083***<br>(0.028) | 0.291***<br>(0.032) | 0.049<br>(0.059) | 0.130***<br>(0.039) | 0.510***<br>(0.079) | 0.422***<br>(0.081) |
| ATT     | 0.168**<br>(0.071)  | -0.061*<br>(0.037)   | 0.293***<br>(0.033) | 0.044<br>(0.060) | 0.130***<br>(0.048) | 0.516***<br>(0.068) | 0.431***<br>(0.089) |
| ATT1    | 0.165**<br>(0.072)  | -0.047<br>(0.033)    | 0.297***<br>(0.034) | 0.056<br>(0.063) | 0.129***<br>(0.045) | 0.539***<br>(0.067) | 0.426***<br>(0.086) |
| ATT 2   | 0.163**<br>(0.070)  | -0.057<br>(0.041)    | 0.293***<br>(0.033) | 0.042<br>(0.060) | 0.132***<br>(0.048) | 0.516***<br>(0.067) | 0.426***<br>(0.087) |
| ATT 3   | 0.159**<br>(0.071)  | -0.043<br>(0.039)    | 0.297***<br>(0.035) | 0.055<br>(0.063) | 0.129***<br>(0.046) | 0.541***<br>(0.064) | 0.420***<br>(0.084) |

Panel A: without covariate adjustment; Panel B: With Covariate adjustment. Figures in parentheses are robust standard errors. \*p<.10; \*\*p<.05; \*\*\*p<.01.

Table 2.4A Retained variables in the adoption estimations with covariate adjustments.

|       | Manure    |             | Mulch     |           | Trenches  |           | ISFWC     |           |
|-------|-----------|-------------|-----------|-----------|-----------|-----------|-----------|-----------|
|       | SMD       | ANCOVA      | SMD       | ANCOVA    | SMD       | ANCOVA    | SMD       | ANCOVA    |
| ITT   | TLU       | Radio       | TLU       | TLU       | None      | None      | None      | None      |
| ATT   | Land, TLU | Land, Radio | Land, TLU | Land, TLU | Land      | Land      | Land      | Land      |
| ATT 1 | Land, TLU | Land, Radio | Land, TLU | Land, TLU | Land      | Land      | Land      | Land      |
| ATT 2 | Land, TLU | Land, Radio | Land, TLU | Land, TLU | Land      | Land      | Land      | Land      |
| ATT 3 | Land, TLU | Land, Radio | Land, TLU | Land, TLU | Land, TLU | Land, TLU | Land, TLU | Land, TLU |

Note: The variables are defined in the descriptives in Table 2.1 in the main text.

Table 2.5A Retained variables in the welfare estimations with covariate adjustments.

|              | Yield     |           | Marketed surplus         |               | Household income   |                                      |
|--------------|-----------|-----------|--------------------------|---------------|--|--------------------------------------|
|              | SMD       | ANCOVA    | SMD                      | ANCOVA        | SMD  | ANCOVA                               |
| <b>ITT</b>   | None      | None      | Education, TV            | TV            | Education, TV, Radio, Bicycle, TLU, Motorcycle, Assets       | Education, Radio, TLU, Assets        |
| <b>ATT</b>   | Land      | Land      | Education, TV, Land      | TV, Land      | Education, TV, Land, Radio, Bicycle, TLU, Assets, Motorcycle | Education, Land, Radio, TLU, Assets, |
| <b>ATT 1</b> | Land      | Land      | Education, TV, Land      | TV, Land, TLU | Education, TV, Land, Radio, Bicycle, TLU, Assets, Motorcycle | Education, Land, Radio, TLU, Assets  |
| <b>ATT 2</b> | Land      | Land      | Education, TV, Land      | TV, Land, TLU | Education, TV, Land, Radio, Bicycle, TLU, Assets, Motorcycle | Education, Land, Radio, TLU, Assets  |
| <b>ATT 3</b> | Land, TLU | Land, TLU | Education, TV, Land, TLU | TV, Land, TLU | Education, TV, Land, Radio, Bicycle, TLU, Assets, Motorcycle | Education, Land, Radio, TLU, Assets  |

Note: The variables are defined in the descriptives in Table 1 in the main text.

Table 2.6A Ex-post Minimum Detectable Effect (MDE) estimations

| Outcome        | ITT   | ATT   | ATT1  | ATT2  | ATT3  | MDE   |
|----------------|-------|-------|-------|-------|-------|-------|
|                | (1)   | (2)   | (3)   | (4)   | (5)   | (6)   |
| <b>Panel A</b> |       |       |       |       |       |       |
| Manure         | 0.153 | 0.177 | 0.194 | 0.187 | 0.206 | 0.063 |
| Mulch          | 0.217 | 0.248 | 0.270 | 0.260 | 0.284 | 0.062 |
| Trenches       | 0.047 | 0.055 | 0.060 | 0.058 | 0.063 | 0.056 |
| ISFM           | 0.117 | 0.135 | 0.148 | 0.142 | 0.156 | 0.062 |
| Yield          | 0.674 | 0.778 | 0.853 | 0.816 | 0.898 | 0.670 |
| Sales          | 0.150 | 0.176 | 0.195 | 0.185 | 0.205 | 0.035 |
| Income         | 1.825 | 2.121 | 2.313 | 2.220 | 2.432 | 1.149 |
| <b>Panel B</b> |       |       |       |       |       |       |
| Manure         | 0.190 | 0.215 | 0.241 | 0.225 | 0.253 | 0.063 |
| Mulch          | 0.244 | 0.273 | 0.307 | 0.285 | 0.322 | 0.062 |
| Trenches       | 0.049 | 0.058 | 0.066 | 0.061 | 0.069 | 0.056 |
| ISFM           | 0.136 | 0.147 | 0.166 | 0.153 | 0.175 | 0.062 |
| Yield          | 0.690 | 0.835 | 0.944 | 0.870 | 1.067 | 0.670 |
| Sales          | 0.167 | 0.187 | 0.213 | 0.195 | 0.224 | 0.035 |
| Income         | 2.385 | 2.829 | 3.166 | 2.967 | 3.340 | 1.149 |

Notes: Panels A and B contain estimates without and with covariate adjustment, respectively. Columns 1 to 5 indicate actual treatment effects obtained in the study for the ANCOVA estimations for the intent to treat (ITT), the average treatment effects on the treated for those who participated in any kind of session (ATT), audio-visual sessions (ATT1), hands-on sessions (ATT2) and both audio-visual and hands-on sessions (ATT3). Based on our study design of 3 clusters in the control group and 3 clusters in the treatment group and the actual households sampled at baseline, we calculate the ex-post MDE, i.e., the minimum impact we would have needed to have been powered to detect an effect assuming power 80% and significance level of 0.05. The intra-cluster correlation (ICC) is estimated using the *loneway* command in *Stata* for survey data for each outcome at the time of the follow-up survey.

## Difference-in-Differences (DID) Results

### *Intent to Treat (ITT) Effects*

Table 2.7A DID ITT Estimates of the effects of the extension-based campaign on the outcomes

|              | (1)     | (2)     | (3)      | (4)     | (5)     | (6)                 | (7)                 |
|--------------|---------|---------|----------|---------|---------|---------------------|---------------------|
| VARIABLES    | Manure  | Mulch   | Trenches | ISFWC   | Yield   | Marketed<br>surplus | Household<br>income |
| Panel A      |         |         |          |         |         |                     |                     |
| ITT          | 0.265   | 0.315   | 0.211    | 0.283   | 1.423   | 0.135               | 0.078               |
|              | (0.063) | (0.068) | (0.108)  | (0.069) | (1.552) | (0.034)             | (1.072)             |
|              | [0.008] | [0.006] | [0.109]  | [0.009] | [0.401] | [0.011]             | [0.945]             |
|              | {0.033} | {0.033} | {0.129}  | {0.033} | {0.313} | {0.037}             | {0.514}             |
|              | ⟨1.000⟩ | ⟨1.000⟩ | ⟨0.978⟩  | ⟨0.001⟩ | ⟨1.000⟩ | ⟨1.000⟩             | ⟨0.294⟩             |
| Observations | 860     | 860     | 860      | 860     | 860     | 860                 | 860                 |
| Panel B      |         |         |          |         |         |                     |                     |
| ITT          | 0.265   | 0.315   | 0.211    | 0.283   | 1.423   | 0.135               | 0.078               |
|              | (0.057) | (0.061) | (0.098)  | (0.062) | (1.404) | (0.031)             | (0.971)             |
|              | [0.000] | [0.000] | [0.031]  | [0.000] | [0.311] | [0.000]             | [0.936]             |
|              | {0.001} | {0.001} | {0.041}  | {0.001} | {0.192} | {0.001}             | {0.441}             |
|              | ⟨0.992⟩ | ⟨1.000⟩ | ⟨0.002⟩  | ⟨0.004⟩ | ⟨1.000⟩ | ⟨1.000⟩             | ⟨0.997⟩             |
| Observations | 860     | 860     | 860      | 860     | 860     | 860                 | 860                 |

Notes: ISFWC is a package combination of manure, mulch, and trenches. 1 USD=3750 UGX (Uganda shillings). All the standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), which are produced using 2,000 draws, are provided in ⟨diamond brackets⟩. FDR = false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively.

## Average Treatment on the Treated (ATT) Effects

Table 2.8A DID ATT Estimates of the effects of participation in the audio-visual sessions on the outcomes

|                   | (1)     | (2)     | (3)      | (4)     | (5)     | (6)              | (7)              |
|-------------------|---------|---------|----------|---------|---------|------------------|------------------|
| VARIABLES         | Manure  | Mulch   | Trenches | ISFWC   | Yield   | Marketed surplus | Household income |
| Panel A           |         |         |          |         |         |                  |                  |
| ATT1 Audio-visual | 0.218   | 0.098   | 0.181    | 0.275   | 0.589   | 0.148            | 0.700            |
|                   | (0.120) | (0.091) | (0.093)  | (0.073) | (1.306) | (0.061)          | (1.432)          |
|                   | [0.071] | [0.282] | [0.051]  | [0.000] | [0.652] | [0.016]          | [0.625]          |
|                   | {0.089} | {0.263} | {0.073}  | {0.001} | {0.425} | {0.038}          | {0.417}          |
|                   | ⟨0.034⟩ | ⟨0.141⟩ | ⟨0.030⟩  | ⟨0.003⟩ | ⟨0.475⟩ | ⟨0.021⟩          | ⟨0.453⟩          |
| Observations      | 860     | 860     | 860      | 860     | 860     | 860              | 860              |
| Panel B           |         |         |          |         |         |                  |                  |
| ATT1 Audio-visual | 0.238   | 0.095   | 0.200    | 0.275   | 0.575   | 0.131            | 1.870            |
|                   | (0.130) | (0.099) | (0.071)  | (0.088) | (1.164) | (0.060)          | (1.275)          |
|                   | [0.067] | [0.337] | [0.005]  | [0.002] | [0.621] | [0.029]          | [0.143]          |
|                   | {0.070} | {0.196} | {0.012}  | {0.006} | {0.290} | {0.041}          | {0.112}          |
|                   | ⟨0.149⟩ | ⟨0.430⟩ | ⟨0.024⟩  | ⟨0.117⟩ | ⟨0.555⟩ | ⟨0.117⟩          | ⟨0.180⟩          |
| Observations      | 860     | 860     | 860      | 860     | 860     | 860              | 860              |

Notes: ISFWC is a package combination of manure, mulch, and trenches. 1 USD=3750 UGX (Uganda shillings). All the standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), which are produced using 2,000 draws, are provided in ⟨diamond brackets⟩. FDR = false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively.

Table 2.9A DID ATT Estimates of the effects of participation in the hands-on sessions on the outcomes

|               | (1)     | (2)     | (3)      | (4)     | (5)     | (6)              | (7)              |
|---------------|---------|---------|----------|---------|---------|------------------|------------------|
| VARIABLES     | Manure  | Mulch   | Trenches | ISFWC   | Yield   | Marketed surplus | Household income |
| Panel A       |         |         |          |         |         |                  |                  |
| ATT2 Hands-on | 0.284   | 0.106   | 0.248    | 0.304   | -0.112  | 0.215            | 1.067            |
|               | (0.122) | (0.102) | (0.100)  | (0.112) | (1.403) | (0.048)          | (1.480)          |
|               | [0.020] | [0.297] | [0.013]  | [0.007] | [0.937] | [0.000]          | [0.471]          |
|               | {0.042} | {0.263} | {0.038}  | {0.033} | {0.514} | {0.001}          | {0.346}          |
|               | ⟨0.013⟩ | ⟨0.164⟩ | ⟨0.012⟩  | ⟨0.013⟩ | ⟨0.904⟩ | ⟨0.001⟩          | ⟨0.286⟩          |
| Observations  | 860     | 860     | 860      | 860     | 860     | 860              | 860              |
| Panel B       |         |         |          |         |         |                  |                  |
| ATT2 Hands-on | 0.305   | 0.106   | 0.260    | 0.312   | -0.174  | 0.209            | 1.984            |
|               | (0.121) | (0.107) | (0.079)  | (0.120) | (1.360) | (0.053)          | (1.263)          |
|               | [0.012] | [0.323] | [0.001]  | [0.010] | [0.898] | [0.000]          | [0.116]          |
|               | {0.023} | {0.193} | {0.005}  | {0.020} | {0.441} | {0.001}          | {0.097}          |
|               | ⟨0.050⟩ | ⟨0.450⟩ | ⟨0.117⟩  | ⟨0.184⟩ | ⟨0.784⟩ | ⟨0.050⟩          | ⟨0.250⟩          |
| Observations  | 860     | 860     | 860      | 860     | 860     | 860              | 860              |

Notes: ISFWC is a package combination of manure, mulch, and trenches. 1 USD=3750 UGX (Uganda shillings). All the standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), which are produced using 2,000 draws, are provided in ⟨diamond brackets⟩. FDR = false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively.

Table 2.10A DID ATT Estimates of the effects of participation in both the audio-visual and hands-on sessions on the outcomes

|              | (1)     | (2)     | (3)      | (4)     | (5)     | (6)                 | (7)                 |
|--------------|---------|---------|----------|---------|---------|---------------------|---------------------|
| VARIABLES    | Manure  | Mulch   | Trenches | ISFWC   | Yield   | Marketed<br>surplus | Household<br>income |
| Panel A      |         |         |          |         |         |                     |                     |
| ATT3 Both    | 0.307   | 0.085   | 0.239    | 0.351   | 0.017   | 0.183               | 2.036               |
|              | (0.137) | (0.096) | (0.100)  | (0.100) | (1.475) | (0.054)             | (1.380)             |
|              | [0.025] | [0.376] | [0.017]  | [0.000] | [0.991] | [0.001]             | [0.140]             |
|              | {0.046} | {0.300} | {0.038}  | {0.001} | {0.532} | {0.008}             | {0.155}             |
|              | ⟨0.015⟩ | ⟨0.214⟩ | ⟨0.013⟩  | ⟨0.005⟩ | ⟨0.992⟩ | ⟨0.005⟩             | ⟨0.058⟩             |
| Observations | 860     | 860     | 860      | 860     | 860     | 860                 | 860                 |
| Panel B      |         |         |          |         |         |                     |                     |
| ATT3 Both    | 0.329   | 0.074   | 0.249    | 0.357   | -0.019  | 0.161               | 3.179               |
|              | (0.146) | (0.103) | (0.067)  | (0.117) | (1.384) | (0.052)             | (1.504)             |
|              | [0.024] | [0.468] | [0.000]  | [0.002] | [0.989] | [0.002]             | [0.035]             |
|              | {0.037} | {0.261} | {0.001}  | {0.006} | {0.441} | {0.006}             | {0.044}             |
|              | ⟨0.110⟩ | ⟨0.552⟩ | ⟨0.081⟩  | ⟨0.052⟩ | ⟨0.963⟩ | ⟨0.052⟩             | ⟨0.110⟩             |
| Observations | 860     | 860     | 860      | 860     | 860     | 860                 | 860                 |

Notes: ISFWC is a package combination of manure, mulch, and trenches. 1 USD=3750 UGX (Uganda shillings). All the standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), which are produced using 2,000 draws, are provided in ⟨diamond brackets⟩. FDR = false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively.

Table 2.11A DID ATT Estimates of the effects of participation in any training session on the outcomes

|                   | (1)     | (2)     | (3)      | (4)     | (5)     | (6)              | (7)              |
|-------------------|---------|---------|----------|---------|---------|------------------|------------------|
| VARIABLES         | Manure  | Mulch   | Trenches | ISFWC   | Yield   | Marketed surplus | Household income |
| Panel A           | 0.209   | 0.126   | 0.198    | 0.242   | 0.461   | 0.184            | -0.153           |
| ATT (Any session) | (0.110) | (0.097) | (0.093)  | (0.093) | (1.327) | (0.051)          | (1.626)          |
|                   | [0.059] | [0.193] | [0.033]  | [0.009] | [0.728] | [0.000]          | [0.925]          |
|                   | {0.081} | {0.183} | {0.054}  | {0.033} | {0.447} | {0.001}          | {0.514}          |
|                   | ⟨0.031⟩ | ⟨0.098⟩ | ⟨0.019⟩  | ⟨0.015⟩ | ⟨0.587⟩ | ⟨0.005⟩          | ⟨0.887⟩          |
| Observations      | 860     | 860     | 860      | 860     | 860     | 860              | 860              |
| Panel B           |         |         |          |         |         |                  |                  |
| ATT (Any session) | 0.229   | 0.127   | 0.218    | 0.244   | 0.420   | 0.183            | 0.771            |
|                   | (0.112) | (0.102) | (0.078)  | (0.101) | (1.259) | (0.056)          | (1.269)          |
|                   | [0.040] | [0.214] | [0.005]  | [0.015] | [0.739] | [0.001]          | [0.544]          |
|                   | {0.048} | {0.160} | {0.012}  | {0.026} | {0.351} | {0.005}          | {0.269}          |
|                   | ⟨0.150⟩ | ⟨0.600⟩ | ⟨0.050⟩  | ⟨0.300⟩ | ⟨0.750⟩ | ⟨0.050⟩          | ⟨0.500⟩          |
| Observations      | 860     | 860     | 860      | 860     | 860     | 860              | 860              |

Notes: ISFWC is a package combination of manure, mulch, and trenches. 1 USD=3750 UGX (Uganda shillings). All the standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets while Randomisation-t p-values following Young (2019), which are produced using 2,000 draws, are provided in ⟨diamond brackets⟩. FDR = false discovery rate. Panels A and B contain estimates without and with covariate adjustment respectively.

## CHAPTER 3

### **The Impact of an Extension-based Campaign and the Adoption of Integrated Soil Fertility and Water Conservation Technologies on Household Food Security: Experimental Evidence from Uganda**

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#### **Abstract**

The rising global population, increasing food demand, and mounting pressure on land resources necessitate sustainable agricultural intensification to enhance productivity while conserving the environment. Integrated soil fertility and water conservation (ISFWC) practices are vital sustainable intensification techniques, associated with improved yields, incomes, and food and nutrition security. However, their adoption rates remain low, primarily due to limited farmer access to information. Public extension systems, though tasked with knowledge dissemination, are often overburdened and understaffed. Development partner initiatives help to bridge these gaps. This study evaluates the impact of an extension-based campaign promoting ISFWC technologies namely, mulching, manure application, and trenches, implemented through a randomized controlled trial. Utilizing diverse communication channels, the campaign provided agronomic information to farmers. Our findings reveal that the campaign significantly increased ISFWC adoption, crop incomes, and improved food and nutrition security. The key determinants of adoption included household head literacy, membership in farmer groups, and household wealth. The actual uptake of ISFWC technologies markedly enhanced household food security and crop revenues. This study provides experimental evidence underscoring the value of targeted agricultural extension initiatives in fostering sustainable practices and improving smallholder household welfare. The policy recommendations include expanding agricultural extension services to ensure equitable access to knowledge, especially in underserved areas, and combining practical, hands-on training with theoretical knowledge in farmer programs alongside promoting ISFWC practices through subsidies and demonstration schemes.

### 3.1 Introduction

The world's population has been steadily increasing and is projected to grow by two billion, reaching approximately ten billion by 2050 (FAO, 2017; WPP, 2019). More than half of this growth is expected to occur in Africa, particularly in Sub-Saharan Africa (SSA) where the population is predicted to double in the next three decades (WPP, 2019). With an annual population growth rate of three percent, Uganda is one of the countries with the highest population growth rates in SSA and globally according to the World Population Prospects (WPP) (WPP, 2015). Its current populace of 41 million people is expected to increase two-and-a-half times by 2050 (UBOS, 2021).

With Uganda's rapidly growing population, the demand for food is increasing sharply, and if unmet, it could exacerbate hunger, malnutrition, and food insecurity. Approximately 40% of Uganda's population is undernourished (NPA, 2018), and the country remains among the world's poorest (UNDP, 2020). The high population growth coupled with limited resources, makes it increasingly challenging to eradicate poverty and inequality, address hunger and malnutrition, and provide essential services. Achieving the Sustainable Development Goals (SDGs), particularly those targeting eradicating poverty, hunger, and food insecurity, relies greatly on enhancing agricultural productivity, which remains a cornerstone for sustainable development in Uganda and other developing countries (UBOS, 2021). The agricultural sector contributes 24% to Uganda's Gross Domestic Product, 35% to its export earnings, and employs 68% of the labour force (World Bank, 2021). Rural livelihoods' reliance on rain-fed agriculture intensifies their vulnerability to climate change which has hampered the production of key crops like maize, beans, sorghum, cassava, coffee, and banana (Wichern et al., 2019). Particularly, the yields of the green-cooking banana, a major cash and food crop, are inherently low due to drought stress, moisture deficit, and poor soil fertility (Sabiiti et al., 2018; Van Asten et al., 2011). Continuous cropping without replenishing nutrients lost through mining and runoff, combined with the lack of organic amendments, results in soil exhaustion and declining agricultural productivity (Nyombi et al., 2010). This calls for sustainable agricultural intensification practices that boost yields while addressing current and future threats to food security, farmer welfare, and ecosystem services (Shiferaw et al., 2013). Such practices include Integrated Soil Fertility and Water Conservation (ISFWC) practices like mulching, manure

application, and constructing drainage channels known as trenches (Abdulai et al., 2011; Kihara et al., 2022).

Empirical evidence shows that adoption of ISFWC and related technologies in rural low-income settings improves the welfare of smallholder families through improved yields, higher incomes, and better food and nutrition security outcomes (Abdulai & Huffman, 2014; Hörner & Wollni, 2021; Issahaku & Abdulai, 2019). ISFWC technologies can enhance agricultural productivity and promote environmental sustainability, playing a vital role in achieving food security and poverty alleviation goals (Pan et al., 2018). However, the farmers' adoption rates of ISFWC and related technologies are low due to limited access to information (Abdulai, 2023; Adolwa et al., 2018).

The dissemination of agricultural information to farmers is primarily the responsibility of the public agricultural extension system. By providing information, extension services play a critical role in enhancing farmers' capacity to innovate. However, Uganda's public extension system faces significant challenges, including resource constraints and limited outreach. According to the National Planning Authority (NPA) in Uganda, only 2,000 extension officers serve over five million farmers, resulting in a ratio of one extension officer per 2,500 farmers (NPA, 2018; UBOS, 2020). This ratio is far worse compared to Tanzania (1:831) and Ghana (1:1850) (Mabaya et al., 2017; MoFA, 2019). Such severe understaffing hampers the diffusion and adoption of agricultural technologies, leaving many farming communities underserved and limiting productivity improvements (Benin et al., 2011).

A study conducted in Uganda's banana farming systems observed that farmers were keen to apply sustainable agricultural intensification practices perceived to offer multiple benefits such as enhanced productivity, soil fertility improvement, and environmental conservation but they were majorly constrained by limited information and insufficient knowledge (Ochola et al., 2013). To bridge the knowledge and extension gap, we collaborated with other stakeholders to implement the extension-based campaign as part of the banana agronomy project in the country's major banana-growing regions, providing farmers with information on agricultural technologies. The campaign utilized various information dissemination channels including radio broadcasts, conventional lecture trainings, video shows, demonstration plots, and farmer field days to promote an integrated soil fertility and water

conservation package, comprising manure, mulch, and trenches. We implemented the campaign in an experimental setting, where the treatment group received information through all dissemination channels, while the control group had access only to radio broadcasts. The campaign aimed to enhance smallholder farmers' welfare by creating awareness and facilitating the adoption of practices that would boost productivity and consequently increase incomes, improve household food and nutrition security, and reduce poverty.

Our study addresses a critical gap in the literature by providing a nuanced analysis of the relationship between information dissemination, technology adoption, and household welfare. While several experimental studies have assessed the impact of information dissemination interventions on the adoption of agricultural technologies and outcomes like yields (Dhehibi et al., 2022; Kondylis et al., 2017; Yitayew et al., 2021), they do not isolate the specific effects of adoption on household welfare. This understanding is crucial for end users, policymakers, and stakeholders to promote sustained technology uptake. Furthermore, a few existing studies examining the link between the uptake of agricultural practices and welfare outcomes are often cross-sectional (Abdulai & Huffman, 2014; Issahaku & Abdulai, 2019), merely controlling for extension access without capturing the causal impact of access to information on adoption. Our experimental study bridges these gaps by examining the effect of extension access on the uptake of ISFWC measures and the subsequent impact of adoption on crop revenues and household food security. This contribution provides robust evidence to inform strategies for scaling up agricultural technologies effectively.

Our findings show that the campaign significantly increased the uptake of the ISFWC package by rural smallholder farmers. The intervention also increased annual revenues from banana production by 25 U.S. dollars per acre and improved their food security statuses through more diverse diets and increased food access. Furthermore, the smallholder farm households that adopted the ISFWC package increased their annual banana revenues by over twelvefold, equivalent to 308 U.S. dollars per acre, diversified their diets by incorporating eight additional food groups, and had better access to food.

The remainder of this paper is organized as follows: the next section presents the study's context. This is followed by a detailed description of the experimental design, the data used for analysis, and the

estimation strategy. In the results section, we evaluate the campaign's impact on the adoption of the ISFWC package, real banana income, and food security levels measured by the household dietary diversity score (HDDS) and the household food insecurity access score (HFIAS). Additionally, we analyze the effect of ISFWC adoption on household welfare and explore heterogeneous treatment effects using machine learning techniques. The final section discusses the conclusions and implications of our findings.

### **3.2 Study context**

Uganda is an agricultural country, with 73% of its population residing in rural areas and primarily relying on agriculture, which accounts for 24% of the Gross Domestic Product (GDP) and 68% of total employment (UBOS, 2021). The East African highland banana cultivar herein referred to as banana, is one of the major crops cultivated by at least half of the households in the country (UBOS, 2020). It is an important source of income and food for millions of households (Kikulwe et al., 2019; Mbabazi et al., 2021). Uganda leads banana production in East and Central Africa and has the highest per capita consumption of the crop globally (Kikulwe et al., 2019). The Bananas contribute 17% of the population's daily caloric intake and provide an affordable source of vitamins A, C, and B6 (Fiedler et al., 2013). Various parts of the banana plant serve domestic and industrial purposes: leaves and pseudo-stems help maintain soil moisture and fertility when used as mulch; leaf sheaths and fibres are used for thatching, handicrafts, and clothing; leaves are used for wrapping food while steaming; and peels and pseudo-stems provide valuable livestock fodder (Ochola et al., 2013). Additionally, bananas contribute significantly to environmental sustainability by reducing soil erosion on steep slopes, maintaining soil structure, and providing shade for intercropped crops like beans, groundnuts, and coffee (Uwamahoro et al., 2019).

However, banana production in Uganda faces multiple challenges that have led to inherently low yields. These include abiotic constraints such as drought stress (Van Asten et al., 2011) and soil nutrient deficiencies (Wairegi et al., 2010). Poor soil fertility is a persistent problem because of continuous cultivation without sufficient nutrient replenishment and nutrient loss due to increased banana sales (Wairegi et al., 2010). Prolonged dry spells leading to moisture stress further exacerbate the problem of

low yields (Van Asten et al., 2011). Various Integrated Soil Fertility and Water Conservation (ISFWC) practices, such as manure application, mulching, and trenches, have been recommended over the years to address declining soil fertility and water scarcity (Ngetich et al., 2014; Vanlauwe et al., 2017). Evidence from the literature demonstrates that these practices can enhance soil quality, improve water use efficiency, and sustainably increase yields (Kihara et al., 2022; Van Asten et al., 2011). The benefits are significantly greater when these practices are applied in combination rather than individually (Bationo et al., 2007; Kihara et al., 2022).

Manure enriches the soil with nutrients and organic matter, improving its structure, enhancing aeration, and increasing water infiltration and available water capacity, thereby boosting nutrient use efficiency—critical in the low-input systems prevalent in most banana agroecological zones in Uganda (Bationo et al., 2007; Van Asten et al., 2011). Mulch suppresses weeds and improves soil water infiltration and retention. Over time, it decomposes, adding nutrients to the soil and increasing crop yields (Ngetich et al., 2014). Trenches enhance rainwater infiltration and storage, mitigating growth and yield penalties caused by drought stress—a key challenge in the rain-fed banana farming systems (Van Asten et al., 2011). While trenches outperform mulch in trapping runoff and boosting infiltration on sloping terrains, mulch is more effective in reducing soil water loss through evaporation (Kihara et al., 2022). Additionally, mulch sourced externally can serve as a biomass transfer nutrient input, complementing manure to enhance soil nutrient stocks more effectively than recycling nutrients from banana residues alone. When combined, manure and mulch significantly increase soil fertility, especially when the mulch includes externally sourced materials.

Empirical evidence shows that while manure, mulch, and trenches individually improve soil fertility, water use efficiency, and productivity, none alone can meet all requirements (Bationo et al., 2007; Kihara et al., 2022). These practices are complementary, and their combined use as an Integrated Soil Fertility and Water Conservation (ISFWC) package delivers substantial productivity benefits. For instance, Bationo et al. (2007) reported significantly higher yields when combining manure, mulch, and water conservation structures.

Despite extensive evidence highlighting the positive yield benefits of the ISFWC package, its adoption among smallholder farmers has remained stagnant (Kamau et al., 2014; Kassie et al., 2013), primarily due to inadequate information dissemination and knowledge gaps that hinder full implementation (Adolwa et al., 2018; Vanlauwe et al., 2010). Ineffective communication of the performance and benefits of agricultural technologies has created significant gaps between change agents and farmers (Adolwa et al., 2018; Spurk et al., 2020). This issue is particularly critical for ISFWC practices, which are knowledge-intensive and require clear communication about their application and benefits (Spurk et al., 2020; Vanlauwe et al., 2017). Research suggests that farmers have diverse preferences and varying access to information sources (Adolwa et al., 2018; Kikulwe et al., 2019). Our study employed a randomized controlled trial (RCT) to disseminate information on the ISFWC package through multiple channels including radio talk shows, video shows, lecture trainings, farmer field days, and demonstration trials.

### *3.2.1 Experimental design*

We utilized five dissemination channels in our extension campaign, broadly categorized into three: the audio channel, which included radio talk shows; the audio-visual channel, comprising lecture trainings and video shows; and the hands-on dissemination channels, which involved farmer field days and demonstration trials. The same information regarding the ISFWC package was transmitted through each channel, emphasizing how, why, and when each practice should be implemented and the synergistic benefits of adopting the technology package.

We broadcast a twelve-week radio campaign across five radio stations with a wide listenership in Uganda's major banana-growing areas. Thus, farmers in the treatment and control sites had access to the information transmitted through the audio channel. We chose the audio medium as the primary channel because 77% of the sampled households owned radios and identified them as a source of agricultural information at baseline. Radio is a cost-effective means of transmission, capable of raising awareness among large audiences (Dzanku et al., 2020), and has been shown to promote technology adoption when used in a participatory manner (Perkins et al., 2011). Moreover, the radio is typically listened to by all household members, regardless of who owns it, making it an effective tool for reaching

a wide audience. The radio broadcast followed a script developed by the research team. Each week, a live 60-minute talk show in the local language covering a specific agronomic practice was aired, with listeners calling in live to ask questions that were answered on air. To enhance interaction, listeners participated in polls by sending free SMS responses through a toll-free short code, providing their location, gender, and answers. The polls addressed constraints such as challenges in producing marketable banana bunches and difficulties in implementing the soil fertility and water conservation practices. Each talk show was recorded and replayed within the same week, and advertisements ran throughout the week encouraging listeners to tune in. Focus group discussions with farmers in treatment sites helped identify the preferred radio stations and optimal program times. Each talk show featured a panel of at least three members: a research team representative, an extension agent, and a farmer.

The video show was a 75-minute drama entitled “*Banana and I*” enacted in the local language by native farmers from the community as role models. This approach leverages peer influence to stimulate cognitive engagement and encourage attitude and behavioural changes (Bernard et al., 2015). In the drama, an extension officer trains farmers on banana agronomic practices, including integrated soil fertility and water conservation measures, emphasizing these practices' timing, methods, and benefits. The storyline highlighted the advantages of adopting these practices in tandem, illustrating how households implementing them achieved higher yields and improved their incomes and food security status, compared to non-adopters, thereby demonstrating the connection between adoption, productivity, income and food security. We screened the drama using projectors and loudspeakers in communal areas such as schools, churches, trading centres, and sports grounds. Following each screening, interactive discussions were held where viewers shared their insights and asked questions to reinforce learning.

The stakeholders implementing the campaign developed communication materials including a story chart, illustrative posters, and an extension manual for facilitating the farmer lecture trainings. The manual covered modules on various agricultural technologies, including the integrated soil fertility and water conservation measures, while the story chart illustrated the practices in a narrative format. The project team conducted a training of trainers for the agricultural extension officers in each treatment site where they were trained how to use the communication materials to train farmers. The extension officers conducted

trainings fortnightly at the parish level, primarily in communal spaces such as schools and at the sites of farmers hosting demonstration trials. Each lecture training session lasted between 90 and 120 minutes.

During the campaign launch, farmers in each treatment site selected their preferred hosts for the demonstration trials. This approach, recognized as crucial for facilitating peer-to-peer learning among farmers (Sutherland & Marchand, 2021), ensured community ownership of the process. During the establishment of the demonstration plots, the hosts and local leaders mobilized neighbouring farmers who attended the highly participatory sessions, featuring expert guidance, peer discussions, and hands-on practice for each innovation. Monthly monitoring of the demonstration plots by extension agents ensured their effectiveness as learning hubs, where additional practical sessions were conducted.

The campaign team organized the farmer field days alongside local committees, including district officials from the production department, political leaders, and scaling partners. The primary objective was to demonstrate the practical application and benefits of integrated soil and water conservation practices based on site-specific recommendations. Upon arrival, farmers were registered and grouped into clusters of 20 for guided study tours through the host farmer's plantation. Several study points were set up, each addressing a different conservation measure. At each station, posters were displayed, and a farmer, extension officer, and researcher conducted practical demonstrations of the practices.

### *3.2.2 Study area*

The banana agronomy project commenced in 2017, starting with the selection of study sites. Six districts were selected from Uganda's major banana-growing regions, with two districts from each region: central, mid-western, and south-western. One district in each region was randomly assigned to the treatment group, while the other was designated as the control group. One subcounty was randomly selected as the treatment unit within each treatment district, and a corresponding subcounty in each control district was randomly selected as the counterfactual. The treatment group included Nakaseke subcounty in Nakaseke district (central region), Rwimi subcounty in Bunyangabu district (mid-western region), and Birere subcounty in Isingiro district (south-western region). The control group comprised Makulubita subcounty in Luwero district (central region), Busoro subcounty in Kabarole district (mid-

western region), and Rugando subcounty in Rwampara district (south-western region). Figure 3.1 is a map of Uganda showing the study areas.

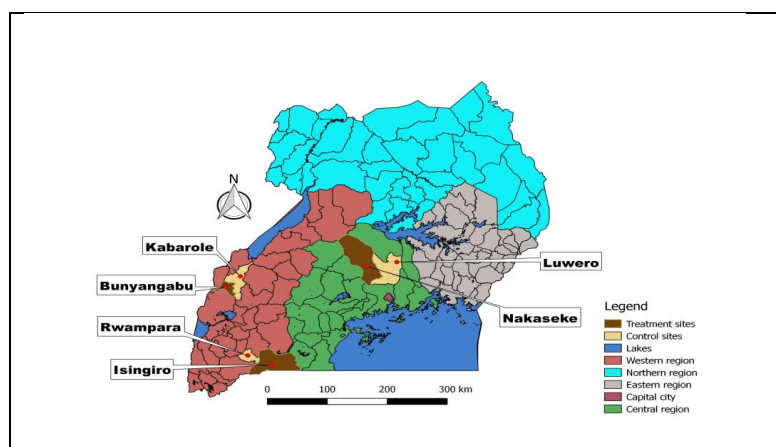


Figure 3.1: Map showing the study area.

### 3.3 Data, descriptive statistics, and estimation strategy

In 2017, before the start of the banana agronomy project, we conducted a baseline survey, interviewing 471 households, 52% of whom were in the treatment group. Using structured questionnaires, we gathered household-level data on demographic, social, and economic characteristics, food security, access to agricultural extension services, sources of agricultural information, and the adoption of integrated soil fertility and water conservation practices. A follow-up survey conducted in 2022 involved interviews with 430 households, reflecting an attrition rate of nine percent. Although the attrition rate is low, we assess the potential influence of attrition bias on the treatment impact, as shown in Table 3.1A in the appendix. The results indicate that attrition does not have a statistically significant effect on the treatment or other control variables, confirming the absence of attrition bias in our study.

### 3.3.1 Balance of Randomization

Table 3.1 Descriptive statistics and balance tests

|                                       | Pooled Sample |         | Treatment group |         | Control group |        | Mean difference |
|---------------------------------------|---------------|---------|-----------------|---------|---------------|--------|-----------------|
|                                       | Mean          | SD      | Mean            | SD      | Mean          | SD     | Treated-Control |
| <u>Outcome variables</u>              |               |         |                 |         |               |        |                 |
| ISFWC adoption (1=Yes)                | 0.144         | 0.352   | 0.118           | 0.323   | 0.173         | 0.379  | -0.055*         |
| HDDS                                  | 7.620         | 2.095   | 7.606           | 2.083   | 7.636         | 2.113  | -0.030          |
| HFIAS                                 | 4.248         | 5.267   | 3.919           | 5.134   | 4.609         | 5.397  | -0.690          |
| Real banana income (\$/Acre)          | 47.453        | 86.760  | 54.135          | 94.366  | 40.148        | 77.145 | 13.987*         |
| <u>Control variables</u>              |               |         |                 |         |               |        |                 |
| Household size                        | 5.811         | 2.544   | 5.939           | 2.564   | 5.671         | 2.521  | 0.268           |
| Gender of household head (1=Male)     | 0.781         | 0.414   | 0.809           | 0.394   | 0.751         | 0.433  | 0.058           |
| Age of household head (years)         | 50.798        | 14.882  | 50.000          | 14.126  | 51.671        | 15.652 | -1.671          |
| Household head's years of education   | 6.342         | 4.269   | 6.289           | 4.256   | 6.400         | 4.292  | -0.111          |
| Total land owned (acres)              | 5.616         | 9.990   | 6.636           | 10.939  | 4.501         | 8.726  | 2.136**         |
| Household head is a farmer (1=Yes)    | 0.851         | 0.356   | 0.870           | 0.337   | 0.831         | 0.375  | 0.039           |
| Household owns a phone (1=Yes)        | 0.856         | 0.352   | 0.862           | 0.346   | 0.849         | 0.359  | 0.013           |
| Household owns a radio (1=Yes)        | 0.766         | 0.424   | 0.752           | 0.433   | 0.782         | 0.414  | -0.030          |
| Log of total value of assets          | 13.164        | 2.320   | 13.384          | 2.308   | 12.924        | 2.314  | 0.459**         |
| Tropical Livestock Units (TLU)        | 1.439         | 6.252   | 1.683           | 8.345   | 1.172         | 2.392  | 0.511           |
| Credit access-not constrained (1=Yes) | 0.569         | 0.496   | 0.606           | 0.490   | 0.529         | 0.500  | 0.077           |
| Belong to a farmer group (1=Yes)      | 0.463         | 0.499   | 0.472           | 0.500   | 0.453         | 0.499  | 0.018           |
| Distance to agric market (minutes)    | 23.222        | 218.084 | 36.616          | 280.504 | 2.889         | 2.263  | 33.727          |
| Number of observations                | 471           |         | 246             |         | 225           |        |                 |

SD is the standard deviation. \*, \*\*, \*\*\* denote that the difference is at 10%, 5% and 1% level, respectively.

Table 3.1 presents descriptive statistics and covariate balancing tests, assessing the effectiveness of the randomization procedure. Most baseline variables are not significantly different between treatment and control groups, indicating minimal concern for randomization bias. While ISFWC technology package utilization was slightly lower at baseline in the treatment group, banana income per acre was higher. Food security metrics, including the Household Dietary Diversity Score (HDDS) and Household Food Insecurity Access Score (HFIAS), were balanced across both groups. A few covariates, including total land owned and asset value, were unbalanced, so baseline covariates are included in the analyses to enhance estimate precision.

### 3.3.2 Estimation Strategy

#### 3.3.2.1 Impact of the Campaign on the Outcomes

A simple approach to estimating the treatment effects involves obtaining the single mean difference (SMD) using a model that includes only observations from the follow-up survey. This SMD model is estimated using ordinary least squares (OLS) and presented in Equation (1) below.

$$Y_{ij1} = \alpha_1 + \beta_T \text{Treat}_j + \beta_X X_{ij0} + \gamma L_i + \varepsilon_{ij1} \quad (1)$$

where:  $Y_{ij1}$  is the outcome variable of interest namely: adoption of the ISFWC package, real banana revenue (in U.S. dollars per acre), and food security measures comprising the Household Dietary Diversity Score (HDDS), and the Household Food Insecurity Access Score (HFIAS) for farm household  $i$  in subcounty  $j$  at follow-up.  $\alpha_1$  is the mean for the control group.  $\text{Treat}_j$  is a binary variable equal to 1 if household  $i$  is in the treatment subcounty  $j$ , 0 for the control.  $\beta_T$  is the impact estimator for the treatment which is also known as the intent to treat (ITT);  $X_{ij0}$  is a vector of control variables for baseline covariates.  $\beta_X$  represents the coefficients of the baseline covariates.  $L_i$  represents location-fixed effects and  $\gamma$  are the corresponding coefficients.  $\varepsilon_{ij1}$  is a random error term clustered at the subcounty level.

The cross-sectional SMD model shown in equation (1) has notable limitations, as it fails to account for potential unobserved heterogeneity and non-zero adoption status at baseline. Since we have baseline and follow up data, we estimate the analysis of covariance (ANCOVA) which provides more precise estimates in such cases (McKenzie, 2012). The ANCOVA model specification shown in equation (2) is similar to the SMD model in equation (1) but includes baseline values of the outcome variable ( $Y_{ij0}$ ) as a control, with  $\beta_Y$  is the corresponding coefficient, and the rest of the parameters are as shown in equation (1). McKenzie (2012) demonstrates that when the correlation between baseline and follow-up outcomes is low (i.e., less than 0.5), ANCOVA improves both power and efficiency. The autocorrelation is low for all our outcomes except for the Household Food Insecurity Access Score (0.936) as shown in Table A2 in the appendix, and this further justified our use of ANCOVA.

$$Y_{ij1} = \alpha_1 + \beta_T \text{Treat}_j + \beta_X X_{ij0} + \beta_Y Y_{ij0} + \gamma L_i + \varepsilon_{ij1} \quad (2)$$

The difference-in-differences (DID) method can also estimate the intent to treat using the baseline and follow-up data. The DID specification is presented in equation (3).  $Post_t$  is a year dummy that takes a value of 1 for the follow-up period (2022) and 0 at baseline (2017).  $\beta_T$  is the impact estimator for the treatment (intent to treat). The rest of the parameters are as shown in equation (1).

$$Y_{ij} = \alpha_1 + \beta_D Treat_j + \beta_P Post_t + \beta_T (Treat_j * Post_t) + \beta_X X_{ij0} + \gamma L_i + \varepsilon_{ij} \quad (3)$$

In instances with a baseline and one follow-up survey, the ANCOVA specification provides more precise estimates than the DID (McKenzie, 2012). We estimate the DID model as a robustness check.

A potential challenge in our study's inference is the risk of type I errors arising from multiple outcomes of interest derived from the same dataset. This is a common issue in experimental studies, where significant results may occur purely by chance, even if the treatment has no real effect on the outcomes. Consequently, the null hypothesis might be incorrectly rejected due to multiple hypothesis testing. To mitigate this, we control for the false discovery rate (FDR)—the proportion of false positives among rejected null hypotheses—by employing the sharpened two-stage q-values approach (Anderson, 2008).

### 3.3.2.2 *Impact of adoption of ISFWC technology package on household welfare*

We measure welfare using the annual real banana income (in U.S. dollars per acre) and the household food security status depicted by the Household Dietary Diversity Score (HDDS) and the Household Food Insecurity Access Score (HFIAS). The HDDS measures the number of food groups household members consumed over a seven-day reference period. It is based on 12 food groups namely cereals, tubers and roots, vegetables, fruits, meat and poultry, eggs, fish, pulses and nuts, legumes, milk and milk products, oils and fats, sugar and honey, and spices and condiments (Swindale & Bilinsky, 2006). The HFIAS is a scale built on the premise that food insecurity (in terms of access) triggers predictable reactions and behavioural responses (Coates et al., 2007). The minimum score is 0, representing a household with no reported food insecurity (indicating better food access). The maximum score is 27, reflecting a highly food-insecure household experiencing frequent occurrences of consuming less preferred foods to skipping meals due to insufficient food access (Coates et al., 2007). A higher HDDS indicates better food and nutrition security, while a higher HFIAS reflects greater food insecurity.

To determine the effect of the adoption of the ISFWC package on the household's food security status and real banana income, we estimate the Local Average Treatment Effect (LATE) by analysing the adoption of the package as the endogenous regressor. We use the random treatment assignment as an instrument for actual uptake of the technology package to estimate LATE on the household welfare outcomes. This reveals the effect of adopting Integrated Soil Fertility and Water Conservation (ISFWC) practices on food security and real crop income. The campaign promoted the adoption of manure, mulch, and trenches as a package because of their synergistic benefits. However, only 46% of the households in the treatment group adopted the package. Therefore, estimating the LATE shows the actual significance of adoption on household welfare which provides more insights than the intent to treat which shows the impact of being part of the campaign intervention.

### *3.3.2.3 Treatment Heterogeneity*

Policymakers often seek to understand heterogeneous treatment effects for informed decision-making. In this study, we use generalized random forests, a machine learning method leveraging causal forests, to detect and estimate unbiased heterogeneous treatment effects. This approach provides individualized predictions of treatment effects and allows us to analyze impact heterogeneity across all the control variables listed in Table 1.

## **3.4 Results**

### *3.4.1 Impact of the campaign on ISFWC adoption, crop income, and food security*

We present the treatment effects (ITT) on the uptake of the ISFWC technology package, HDDS, HFIAS, and real banana income using both the single mean difference (SMD) and analysis of covariance (ANCOVA) estimates in Table 3.2. In all our analyses, inference is based on subcounty-level clustered standard errors, with p-values adjusted for multiple hypothesis testing. We compute the sharpened q-value to control for the false discovery rate (FDR) following the procedure outlined in Anderson (2008).

Table 3.2 Impact of the extension-based campaign on ISFWC adoption, food security, and real crop income

|              | Adoption |          | HDDS     |          | HFIAS     |           | Crop Income (USD/acre) |           |
|--------------|----------|----------|----------|----------|-----------|-----------|------------------------|-----------|
|              | SMD      | ANCOVA   | SMD      | ANCOVA   | SMD       | ANCOVA    | SMD                    | ANCOVA    |
|              | (1)      | (2)      | (3)      | (4)      | (5)       | (6)       | (7)                    | (8)       |
| Panel A      |          |          |          |          |           |           |                        |           |
| ITT          | 0.080**  | 0.080*** | 0.667*** | 0.798*** | -0.785**  | -0.816*** | 18.189**               | 24.846*** |
|              | (0.018)  | (0.018)  | (0.088)  | (0.076)  | (0.257)   | (0.082)   | (6.785)                | (6.963)   |
|              | [0.007]  | [0.007]  | [0.001]  | [0.000]  | [0.028]   | [0.000]   | [0.044]                | [0.016]   |
|              | {0.011}  | {0.005}  | {0.005}  | {0.001}  | {0.020}   | {0.001}   | {0.023}                | {0.009}   |
| Control mean | 0.521    | 0.543    | 6.128    | 4.626    | 13.266    | 0.566     | -151.100               | -104.609  |
| Covariates   | YES      | YES      | YES      | YES      | YES       | YES       | YES                    | YES       |
| Observations | 430      | 430      | 430      | 430      | 430       | 430       | 430                    | 430       |
| Panel B      |          |          |          |          |           |           |                        |           |
| ITT          | 0.135*** | 0.136*** | 0.754*** | 0.941*** | -0.623*** | -0.974*** | 14.210***              | 22.927*** |
|              | (0.000)  | (0.001)  | (0.000)  | (0.030)  | (0.000)   | (0.006)   | (0.000)                | (1.953)   |
|              | [0.000]  | [0.000]  | [0.000]  | [0.000]  | [0.000]   | [0.000]   | [0.000]                | [0.000]   |
|              | {0.001}  | {0.001}  | {0.001}  | {0.001}  | {0.001}   | {0.001}   | {0.001}                | {0.001}   |
| Control mean | 0.259    | 0.255    | 8.000    | 5.296    | 3.328     | 0.854     | 60.669                 | 35.573    |
| Covariates   | NO       | NO       | NO       | NO       | NO        | NO        | NO                     | NO        |
| Observations | 430      | 430      | 430      | 430      | 430       | 430       | 430                    | 430       |

Notes: Adoption refers to the ISFWC package, a combination of manure, mulch, and trenches. HDDS is Household Dietary Diversity Score. HFIAS is the Household Food Insecurity Access Scale. Real crop income is banana revenue in US dollars per acre. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets. FDR denotes false discovery rate. \*, \*\*, \*\*\* denote significance at 10%, 5%, and 1% level, respectively based on the adjusted p-values (FDR q-values). Panels A and B contain estimates with and without covariates respectively. SMD is Simple Mean Difference; ANCOVA is Analysis of Covariance.

The results in Table 3.2 indicate that the extension campaign significantly enhanced the adoption of ISFWC measures, increased real banana income, and improved household food and nutrition security. In the treatment group, ISFWC adoption rose by 8%, while annual banana income increased by 25 U.S. dollars per acre. Similarly, Abdulai & Huffman (2014) found that extension access promotes soil and water conservation adoption and boosts crop revenues in Ghana. Additionally, households in the treatment group exhibited improved food security, consuming one additional food group and having

better food access than those in the control group. These findings align with prior research in the region. For instance, De Groote et al. (2016), reported that households with access to extension services adopted improved agricultural technologies and enhanced their diets. More recent quasi-experimental studies in Uganda, such as Brenya & Zhu (2023) and Pan et al. (2018), also confirm that access to agricultural extension services positively impacts food security.

#### *3.4.2 Characteristics of ISFWC Adopters and Non-Adopters*

We analyze differences between ISFWC adopters and non-adopters within the treatment group using follow-up data as shown in Table 3.3. Adopting households are significantly larger, with more members, and have more educated heads who belong to farmer groups. They are also wealthier, as evidenced by higher total asset values. They are more likely to own a phone, and a significantly higher proportion reside in Birere sub-county, in the southwestern region, characterized by steep slopes. Larger household sizes indicate greater labor availability, while higher asset values suggest better wealth status, both of which facilitate the implementation of ISFWC measures. On average, adopting household heads have completed seven years of schooling, equivalent to primary education, compared to 5.5 years among non-adopters. Furthermore, 62% of adopting household heads are members of farmer groups, compared to only 34% of non-adopters.

Table 3.3 Comparison of socioeconomic characteristics of ISFWC Adopters and Non-adopters within the treatment sites

| Variable                               | Adopters   |          | Non-Adopters |          | Test of difference |
|--|------------|----------|--------------|----------|--------------------|
|  | (1)        |          | (2)          |          | (1-2)              |
|  | Mean       | SD       | Mean         | SD       | P value            |
| Household size                         | 6.352      | (2.591)  | 5.634        | (2.427)  | 0.032**            |
| Male household head                    | 0.800      | (0.402)  | 0.732        | (0.445)  | 0.228              |
| Household head's age                   | 54.419     | (14.022) | 56.537       | (15.933) | 0.292              |
| Household head's education (years)     | 7.086      | (4.536)  | 5.504        | (4.140)  | 0.006***           |
| Total land owned (acres)               | 4.985      | (6.440)  | 3.817        | (4.374)  | 0.106              |
| Farmer group membership                | 0.619      | (0.488)  | 0.341        | (0.476)  | 0.000***           |
| Household head's occupation is farming | 0.838      | (0.370)  | 0.854        | (0.355)  | 0.747              |
| Total asset value (log)                | 14.345     | (1.814)  | 13.798       | (1.658)  | 0.018**            |
| Tropical Livestock Units (TLU)         | 1.614      | (3.531)  | 1.109        | (2.723)  | 0.225              |
| Distance to market                     | 5.160      | (4.382)  | 4.303        | (3.960)  | 0.122              |
| Not Credit constrained                 | 0.667      | (0.474)  | 0.618        | (0.488)  | 0.446              |
| Own a phone                            | 0.914      | (0.281)  | 0.813        | (0.391)  | 0.028**            |
| Own a radio                            | 0.829      | (0.379)  | 0.805        | (0.398)  | 0.647              |
| Birere                                 | 0.457      | (0.501)  | 0.293        | (0.457)  | 0.010**            |
| Rwimi                                  | 0.314      | (0.466)  | 0.407        | (0.493)  | 0.150              |
| Nakaseke                               | 0.229      | (0.422)  | 0.301        | (0.460)  | 0.221              |
| <b>Observations</b>                    | <b>105</b> |          | <b>123</b>   |          |                    |

SD is the standard deviation. \*, \*\*, \*\*\* denote that the difference is at 10%, 5% and 1% level, respectively.

### 3.4.3 Impact of ISFWC adoption on crop income, and food security (Local Average Treatment Effects)

A key objective of this study is to assess the impact of adopting integrated soil and water conservation (ISFWC) practices on crop revenue and food and nutrition security outcomes. The analysis of the Local Average Treatment Effects (LATE) reveals the effect of the actual uptake of ISFWC technologies on these outcomes for households in the treatment group. While the Intent-to-Treat (ITT) approach measures the overall impact of an intervention, it does not account for non-compliance (Angrist, 2006). In our study, only 46% of households in the treatment group adopted the ISFWC package, indicating imperfect compliance within the Randomized Controlled Trial (RCT). Consequently, LATE estimates are particularly relevant for policy implications in this context.

Table 3.4 Impact of adoption of ISFWC practices on farmers' food security and real crop income (LATE).

|              | HDDS     |          | HFIAS     |            | Real Crop income (USD/Acre) |            |
|--------------|----------|----------|-----------|------------|-----------------------------|------------|
|              | SMD      | ANCOVA   | SMD       | ANCOVA     | SMD                         | ANCOVA     |
|              | (1)      | (2)      | (3)       | (4)        | (5)                         | (6)        |
| Panel A      |          |          |           |            |                             |            |
| LATE         | 8.288*** | 8.697*** | -9.764*** | -10.136*** | 226.134***                  | 307.764*** |
|              | (0.957)  | (1.019)  | (2.613)   | (2.459)    | (90.919)                    | (85.313)   |
|              | [0.000]  | [0.000]  | [0.000]   | [0.000]    | [0.013]                     | [0.000]    |
|              | {0.001}  | {0.001}  | {0.001}   | {0.001}    | {0.005}                     | {0.001}    |
| Control mean | 1.810    | 1.220    | 18.354    | 6.200      | -268.918                    | -265.589   |
| Covariates   | YES      | YES      | YES       | YES        | YES                         | YES        |
| Observations | 430      | 430      | 430       | 430        | 430                         | 430        |
| Panel B      |          |          |           |            |                             |            |
| LATE         | 5.593*** | 6.278*** | -4.618*** | -7.144***  | 105.395***                  | 166.394*** |
|              | (0.001)  | (0.219)  | (0.001)   | (0.081)    | (0.001)                     | (8.658)    |
|              | [0.000]  | [0.000]  | [0.000]   | [0.000]    | [0.000]                     | [0.000]    |
|              | {0.001}  | {0.001}  | {0.001}   | {0.001}    | {0.001}                     | {0.001}    |
| Control mean | 6.553    | 5.038    | 4.522     | 2.780      | 33.412                      | -6.039     |
| Covariates   | NO       | NO       | NO        | NO         | NO                          | NO         |
| Observations | 430      | 430      | 430       | 430        | 430                         | 430        |

Notes: ISFWC is Integrated Soil Fertility and Water Conservation, a combination of manure, mulch, and trenches. HDDS is Household Dietary Diversity Score. HFIAS is the Household Food Insecurity Access Scale. Real crop income is banana revenue in US dollars per acre. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected "p-values" [i.e., q-values] are in curly brackets. FDR denotes false discovery rate. \*, \*\*, \*\*\* denote significance at 10%, 5%, and 1% level, respectively based on the adjusted p-values (FDR q-values). Panels A and B contain estimates with and without covariate respectively. SMD is Simple Mean Difference; ANCOVA is Analysis of Covariance.

The LATE results, presented in Table 3.4, demonstrate that adopting the ISFWC package significantly increased banana revenue and improved food security. Adopters earned approximately 308 U.S. dollars more per acre per year than non-adopters. These findings align with Abdulai & Huffman (2014), who reported that adopters of soil and water conservation measures with access to extension services achieved significantly higher net crop returns than non-adopters.

Our results further show that the HDDS conditional on adoption was approximately nine food groups, reflecting higher dietary quality. Additionally, adoption reduced household food insecurity, as indicated by a decrease of 10.136 points in the HFIAS. These findings are consistent with Issahaku & Abdulai (2019), who observed that adopting climate-smart agricultural practices significantly increased HDDS and reduced HFIAS.

For all welfare outcomes, the LATE estimates in Table 4 are substantially higher than the corresponding ITT estimates in Table 3.2. For example, the LATE estimate for HDDS is 8.697 (Table 3.4, column 2), compared to the ITT estimate of 0.798 (Table 3.2, column 4). A similar trend is observed for crop revenues. This indicates that the actual uptake of the ISFWC technology package enhances household food and nutrition security, and crop revenue compared to mere exposure to the intervention.

#### 3.4.4 Heterogenous Treatment Effects

Table 3.5 presents the campaign-based extension approach's heterogeneous impacts by pre-treatment covariates for each outcome. While heterogeneity was tested across all control variables, only statistically significant results are reported for brevity. The findings reveal a negative differential impact on the uptake of the ISFWC package among households where the head's primary occupation was farming. Households that were not credit-constrained experienced reduced food insecurity, whereas those with more educated heads had less access to food. No statistically significant heterogeneous treatment effects were observed for the HDDS and crop income outcomes.

Table 3.5 Heterogeneous treatment effects conditional on the pre-treatment characteristics

| Variable  | (1)<br>Adoption      | (2)<br>HDDS | (3)<br>HFIAS        | (4)<br>Crop income |
|---|----------------------|-------------|---------------------|--------------------|
| Not credit constrained                          |                      |             | -2.238**<br>(0.977) |                    |
| Household head's years of education             |                      |             | 0.229**<br>(0.111)  |                    |
| Farming is the household head's main occupation | -0.337***<br>(0.121) |             |                     |                    |
| Observations                                    | 430                  | 430         | 430                 | 430                |

Note: The results are generated through the generalized random forest technique using the *grf* package in R. Standard errors are in parentheses. \*\*\*p < 0.01, \*\*p < 0.05.

### 3.4.5 *Robustness checks*

We conducted three robustness checks to validate our findings. First, we assessed the robustness of our results to adjustments for multiple hypothesis testing across all outcomes considered in the study and confirmed that the findings remain robust. Second, we tested for treatment heterogeneity to evaluate the consistency of results under various disaggregation. Differential treatment effects were identified concerning the household head's education level, primary occupation, and access to credit. Third, we estimated difference-in-differences (DID) models for intent-to-treat (ITT) estimations across all outcomes, with the results presented in Appendix Table 3.3A. The DID findings align with the SMD and ANCOVA ITT estimations in Table 3.2. Empirical evidence suggests that when only one baseline and follow-up survey are available, ANCOVA offers greater statistical power and precision than the DID (McKenzie, 2012).

## 3.5 **Conclusion and policy implications**

The rising global population, coupled with increasing food demand and pressure on land resources, underscores the need for sustainable agricultural intensification to boost land productivity. Integrated soil fertility and water conservation (ISFWC) practices are key sustainable intensification techniques that enhance crop yields while conserving the environment. These practices are associated with improved yields, incomes, and food and nutrition security (Abdulai & Huffman, 2014; Hörner & Wollni, 2021). However, their adoption remains limited due to inadequate access to information among farmers (Abdulai, 2023; Adolwa et al., 2018). Public extension systems that are mandated to provide technical information to the end users are overburdened and understaffed, and struggle to meet the demand for knowledge dissemination. Development partners help to bridge the gap through targeted interventions. Our extension-based campaign is one such initiative designed to promote ISFWC technologies including mulching, manure application, and drainage trenches. Using multiple communication channels, the campaign availed agronomic information to farmers through a randomized controlled trial. Both treatment and control groups had access to radio talk shows, but the treatment group additionally benefited from lecture trainings, video demonstrations, farmer field days, and on-site trials—accommodating farmers' diverse preferences for information sources.

Extensive research has explored the impact of information access on technology adoption and welfare outcomes, particularly yields (e.g. Dhehibi et al., 2022; Kondylis et al., 2017; Yitayew et al., 2021). However, studies directly examining the effects of adoption on smallholder household welfare, particularly within experimental settings remain scarce. This study addresses this gap by providing experimental evidence on the impact of information access on the uptake of the ISFWC package and the effects of adoption on smallholder household welfare depicted by their crop revenues and food security status. This contribution provides valuable insights for enhancing the design and implementation of agricultural extension programs.

Our findings reveal that the extension campaign significantly increased the adoption of the ISFWC technology package, crop incomes, and food and nutrition security. Moreover, household head literacy, membership in farmer groups, and household wealth emerged as key factors influencing the adoption of ISFWC technologies. Notably, the actual uptake of the ISFWC package substantially improves household food security and enhances crop revenues.

These findings have multifaceted policy implications. First, greater investment in and expansion of agricultural extension services is essential to ensure equitable access to knowledge and support, especially for farmers in rural and underserved areas. Second, farmer training programs should emphasize a blend of practical, hands-on learning and theoretical knowledge about soil fertility and water conservation techniques. Lastly, promoting the uptake of integrated practices through subsidies, training initiatives, and demonstration schemes that emphasize their synergistic benefits is crucial for widespread and sustained uptake.

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## Appendix

### Attrition rates

Table 3.1A Attrition correlates

| Variable                                  | Coefficient | Standard error | p-value |
|---|-------------|----------------|---------|
| Treatment                                 | -0.006      | 0.054          | 0.910   |
| Household size                            | 0.005       | 0.012          | 0.676   |
| Gender of household head (1=Male)         | 0.046       | 0.054          | 0.432   |
| Age of household head (years)             | -0.001      | 0.002          | 0.620   |
| Household head's years of education       | -0.001      | 0.006          | 0.822   |
| Total land owned (acres)                  | 0.001       | 0.002          | 0.514   |
| Household head is a farmer (1=Yes)        | -0.063      | 0.035          | 0.131   |
| Household owns a phone (1=Yes)            | -0.000      | 0.031          | 0.996   |
| Household owns a radio (1=Yes)            | 0.033       | 0.039          | 0.432   |
| Log of total value of assets              | -0.005      | 0.012          | 0.661   |
| Tropical Livestock Units (TLU)            | -0.011      | 0.007          | 0.174   |
| Credit access-not constrained (1=Yes)     | 0.021       | 0.030          | 0.519   |
| Belong to a farmer group (1=Yes)          | 0.054       | 0.047          | 0.296   |
| Distance to agricultural market (minutes) | -0.000      | 0.000          | 0.320   |
| Constant                                  | 0.145       | 0.202          | 0.504   |
| Observations                              | 471         |                |         |
| R-squared                                 | 0.039       |                |         |

Table 3.2A Autocorrelations of the outcome variables

| Outcome variables                    | $\rho$ |
|--------------------------------------|--------|
| ISFWC adoption                       | 0.057  |
| HDDS                                 | 0.391  |
| HFIAS                                | 0.936  |
| Real banana income (US Dollars/acre) | 0.485  |

Note: Tetrachoric correlations were used for the binary variables

# ITT Effects

Table 3.3A DID ITT Estimates of the effects of the extension-based campaign on the outcomes

|              | (1)      | (2)     | (3)      | (4)                 |
|--------------|----------|---------|----------|---------------------|
| VARIABLES    | Adoption | HDDS    | HFIAS    | Real crop<br>income |
| Panel A      |          |         |          |                     |
| ITT          | 0.283**  | 1.024** | -0.695** | 0.777               |
|              | (0.069)  | (0.187) | (0.190)  | (10.710)            |
|              | [0.009]  | [0.003] | [0.015]  | [0.945]             |
|              | {0.014}  | {0.013} | {0.016}  | {0.310}             |
| Control mean | -0.075   | 5.641   | 13.564   | -141.951            |
| Covariates   | YES      | YES     | YES      | YES                 |
| Observations | 860      | 860     | 860      | 860                 |
| Panel B      |          |         |          |                     |
| ITT          | 0.283**  | 1.024** | -0.695** | 0.777               |
|              | (0.068)  | (0.185) | (0.188)  | (10.628)            |
|              | [0.009]  | [0.003] | [0.014]  | [0.945]             |
|              | {0.014}  | {0.013} | {0.015}  | {0.310}             |
| Control mean | 0.134    | 8.128   | 2.911    | 43.286              |
| Covariates   | NO       | NO      | NO       | NO                  |
| Observations | 860      | 860     | 860      | 860                 |

Notes: Adoption refers to the ISFWC package, a combination of manure, mulch, and trenches. HDDS is Household Dietary Diversity Score. HFIAS is the Household Food Insecurity Access Scale. Real crop income is banana revenue in US dollars per acre. Standard errors (in parentheses) are clustered at the subcounty level. The p-values [in square brackets] are unadjusted for multiple testing; FDR-corrected “p-values” {i.e., q-values} are in curly brackets. FDR denotes false discovery rate. \*, \*\*, \*\*\* denote significance at 10%, 5%, and 1% level, respectively based on the adjusted p-values (FDR q-values). Panels A and B contain estimates with and without covariates respectively.

## CHAPTER 4

### Information Access, Women's Empowerment, and the Adoption of Agricultural Technologies in Uganda

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#### Abstract

The low adoption of agricultural technologies in Sub-Saharan Africa is attributed to limited access to information. The public agricultural extension systems are understaffed, and provide advisory services mostly to male household heads, excluding women who contribute significant amounts of farm labour. Such biases limit women's access to relevant information and suppress their involvement in household decision-making. In this study, we provide empirical evidence of the impact of an inclusive extension campaign and the mediating role of women's empowerment on the uptake of agricultural technologies. The campaign, implemented through a Randomized Controlled Trial disseminates information pertinent to mulching, manure application, and trenches through radio, video, lecture trainings, demonstration trials, and farmer field days among farmers in major banana-growing regions in Uganda. Various measures were instituted to facilitate women's involvement as role models and participants in the activities, together with men. Our results show that targeting agricultural advisory services to women alongside men and involving them in agricultural, credit, and income decisions, empowers them and significantly influences the adoption of agricultural technologies. Households with empowered women adopt practices that align with prevailing norms and customs in agriculture and benefit them directly like mulch that reduces the time they spend weeding. They also adopt the technology package that provides the best yield benefits. This research underscores the need to design inclusive agricultural extension and advisory services that incorporate initiatives that empower women and enable them to overcome gender-related barriers that constrain the adoption of agricultural technologies to enhance sustainable welfare benefits.

## 4.1 Introduction

Adopting agricultural technologies in rural low-income settings has been associated with numerous welfare benefits for smallholder farmers including increased crop yields (Khonje et al., 2018; Kikulwe et al., 2019), higher incomes (Mbabazi et al., 2021), improved nutrition and food security (Issahaku & Abdulai, 2019) as well as reduced poverty levels (Shahzad & Abdulai, 2020). Despite these benefits, adoption rates in Sub-Saharan Africa remain low, primarily due to limited access to information (Abdulai, 2023; Aker, 2011). Government agricultural extension systems, tasked with information dissemination, are constrained by insufficient resources, leaving many farming communities underserved. Evidence from various countries shows extreme understaffing. In Tanzania, there is one extension officer for every 831 farmers (Mabaya et al., 2017), while Ghana reports a ratio of 1:1850 (MoFA, 2019), and Uganda faces a significant shortfall with 2000 officers serving over five million farmers, resulting in a ratio of 1:2500 (UBOS, 2020). These inadequate extension services hinder the diffusion of agricultural technologies. Development partners try to bridge the gap through short-term, localized technology promotion initiatives.

Agricultural extension systems typically target men despite women's significant contributions to agricultural labour, because men are perceived as the primary decision-makers (Lecoutere et al., 2023; Meinzen-Dick et al., 2010). Women's roles as producers are frequently overlooked, and poor targeting approaches sometimes exclude them from receiving extension services (Doss & Morris, 2001; Farnworth et al., 2018). Consequently, women often have less access to information about productivity-enhancing technologies, limiting their participation in agricultural decision-making and hindering technology adoption (Fisher & Carr, 2015; Lambrecht et al., 2016). Extension service providers assume that men relay information to their spouses, but studies reveal significant intrahousehold information asymmetries, where men often do not share agronomic practices or management decisions with their wives, depriving women of vital information (Fisher & Carr, 2015; Magnan et al., 2015).

Other factors contributing to the lack of information among women farmers include limited financial resources to travel to extension training sites and time constraints due to domestic responsibilities (Magnan et al., 2015). Additionally, the content or delivery methods of the information may neither be

designed to meet women's interests/needs nor acknowledge their role as agricultural producers, making the information less relevant and appealing to them (Lecoutere et al., 2023). Cultural norms restricting women's mobility and interactions with men further limit their participation in training opportunities (Ragasa et al., 2013). Consequently, women rely more on informal, often gender-segregated, networks, which can perpetuate information asymmetries (Magnan et al., 2015). These barriers result in lower adoption rates of improved agricultural practices among women, despite their willingness to adopt (Bryan et al., 2017). Studies show that with equal access to extension services, land, and labour, women are as likely as men to adopt modern agronomic practices, as demonstrated in Ghana (Doss & Morris, 2001) and Kenya (N. S. Kabunga et al., 2012).

Women's disempowerment also constrains their ability to adopt agricultural technologies. Compared to men, women in developing countries are less involved in decision-making and are less likely to own land, often holding smaller plots without secure tenure that hinders long-term investments (Doss et al., 2015, 2021; Kieran et al., 2015). In Uganda, gender disparities among smallholder banana farmers reveal men holding larger plots (3.6 hectares) than women (2.5 hectares), perpetuated by traditional governance and kinship systems (Ochola et al., 2013). Women also face challenges accessing credit, extension services, and farmer organizations, compounded by low income and limited control over productive resources, which restrict their ability to adopt sustainable agricultural practices (Kondylis et al., 2016; Meinzen-Dick et al., 2010; Ragasa et al., 2013). Consequently, women tend to focus on low-investment and low-profit innovations developed through their social networks instead of those promoted by extension workers (Kawarazuka & Prain, 2019).

Literature is replete with studies showing that targeting women with extension and advisory services increases the adoption of agricultural technologies (e.g. Fisher & Carr, 2015; Pan et al., 2018). However, recent research shows that simply offering women technical knowledge may not be sufficient for widespread technology adoption without addressing the gender-specific barriers they face, including disparities in land ownership, minimal involvement in household decision-making, and limited access to financial and other resources (Lambrecht et al., 2016; Lecoutere et al., 2023). A deeper understanding of the links between information access, women's empowerment, and adoption decisions can enhance

the effectiveness of extension systems and improve smallholder livelihoods. However, adoption studies that explicitly analyse these linkages are scarce.

Some studies explore the relationship between women's empowerment and the adoption of agricultural technologies, but they are largely observational (e.g., Euler et al., 2024; Kassie et al., 2020). Kassie et al. (2020) found that women's empowerment, measured using the Abbreviated Women's Empowerment in Agriculture Index (A-WEAI), amplifies the benefits of technology adoption on dietary diversity. However, their study focused only on women, excluding potential impacts on men, a critical oversight given that increases in women's empowerment may sometimes come at the expense of men's empowerment (Quisumbing et al., 2023). Substantial evidence supports the importance of involving both men and women in studies to understand the intrahousehold dynamics that shape gender relations that consequently influence development objectives including technology adoption (Johnson et al., 2018; Quisumbing et al., 2021, 2023; Sraboni et al., 2014). Euler et al. (2024) linked women's bargaining power to the adoption of rust-resistant wheat in Ethiopia, focusing on men and women's participation in decision-making within households. Yet, their study overlooked other empowerment domains, such as leadership, resource access, and time allocation, which are essential for a comprehensive understanding of empowerment (Alkire et al., 2013; H. J. L. Malapit & Quisumbing, 2015).

Recent experimental evidence from Lecoutere et al. (2023) underscores the importance of involving both male and female household co-heads in extension campaigns. Results from their Randomized Controlled Trial (RCT) showed that providing agricultural information directly to women enhanced their knowledge, decision-making roles, adoption rates, and yields. However, their narrow focus on women's roles in agricultural decisions overlooked broader aspects of empowerment, such as financial control, workload, mobility, and group membership which are critical for adoption. Comprehensive approaches that consider intrahousehold dynamics and multidimensional empowerment are essential for driving gender-equitable adoption and development outcomes (Johnson et al., 2018; Quisumbing et al., 2021).

We build on this literature by evaluating the impact of an inclusive extension-based campaign on the empowerment of farmers in Uganda and assess the mediating effect of women's empowerment on the adoption of agricultural technologies. Our campaign, conducted as an RCT, disseminated

information to farmers through various communication channels, including radio talk shows, video screenings, in-person lectures, farmer field days, and demonstration trials. The technologies promoted include mulching, manure application, and trenches, all aimed at improving banana production, a key staple crop. To enhance women's participation, most activities were conducted in the afternoons and decentralized at the parish level to ensure proximity to the venues. Gender-inclusive groups were also established to promote knowledge sharing, collective marketing, savings, and credit access. The findings provide empirical evidence that gender-inclusive extension services empower women by improving their agricultural knowledge, access to financial and productive resources, decision-making autonomy, and group participation, thereby facilitating the adoption of recommended practices.

Our findings show that inclusive extension services empower farmers and boost the adoption of agricultural innovations. Furthermore, women's access to information and involvement in agricultural, credit, and income decisions significantly influence the adoption of agricultural technologies in dual households. This study contributes to the literature on inclusive agricultural extension by addressing intrahousehold information asymmetries and gender disparities in low- and middle-income countries. The rest of the paper is organized as follows: section 4.2 elaborates the study context, section 4.3 describes the data, the methodology is explained in section 4.4, the results are discussed in section 4.5 and section 4.6 concludes with the policy implications of our findings.

## **4.2 Study Context**

### *4.2.1 Agricultural Extension in Uganda*

The agricultural sector is a key pillar of Uganda's economy, contributing 24% to the country's GDP, and employing approximately 65% of the labor force (UBOS, 2021). About 75% of the population resides in rural areas and is largely involved in farming. The government is responsible for providing extension and advisory services to enhance farmers' capacity to innovate. However, the extension system is inefficient due to limited facilitation and understaffing. Recent information from the Uganda Bureau of Statistics (UBOS) indicates that approximately 2,000 extension officers serve over five million farmers, leading to an extension officer-to-farmer ratio of 1:2,500 (UBOS, 2020). Lately, private initiatives and international social enterprises are trying to fill the gap. These include *Viamo's 3-2-1* service, which

provides agricultural information through interactive voice response, and the *m-Omulimisa* platform, through which farmers send SMS messages with questions to agricultural extension officers. However, these services are not widespread.

The public agricultural extension system in Uganda has gone through a transition over the last two decades. In 2000, the National Agricultural Advisory Services (NAADS) was established as a public-private partnership and was widely acclaimed by experts and donors as a model for promoting market-oriented agricultural production by enabling farmers to take control of and demand extension services (Kjær & Joughin, 2019). The NAADS initiative had some gender considerations in its implementation, for instance, through the distribution of dairy cows to women to enhance food security. However, a countrywide impact evaluation revealed that the program was more effective in male-headed households than female-headed ones (Benin et al., 2011). Another study asserted that NAADS was more successful in reaching women and vulnerable groups than privatized extension services (Turyahikayo & Kamagara, 2016). However, in 2014, due to political interference and governance challenges, NAADS was replaced by Operation Wealth Creation (OWC), an initiative managed by the military (Kjær & Joughin, 2019). OWC primarily distributes agricultural inputs with limited informational/advisory support to smallholder farmers. Although the OWC program guidelines emphasize gender equity and non-discrimination, it lacks mechanisms to ensure equitable distribution of inputs, and therefore risks diminishing the gender responsiveness of Uganda's public extension system (Acosta et al., 2019).

A survey on public service delivery revealed that only 16 percent of Uganda's extension agents are women (N. Kabunga et al., 2016). The extension officers are predominantly male and typically deliver information and inputs to men without regard to women's contribution to agriculture. This bias impedes women's ability to make informed decisions, limits their bargaining power within the household, and deters the adoption of agricultural technologies. Previous studies have shown that targeting is crucial for making information effective for specific groups or individuals. For instance, in Mozambique, Kondylis et al. (2016) observe that extension information on sustainable land management reaches male farmers more effectively than female farmers, and is not fully shared between male and female co-heads within the households. They note that adding female extension agents positively impacts awareness and

adoption among female farmers. In the Democratic Republic of Congo, Lambrecht et al. (2016) examine the effectiveness of extension services based on the recipient within a household, and their findings show that adoption rates of integrated soil fertility management practices are highest when both male and female co-heads participate jointly in extension information sessions. There is also considerable evidence in Uganda showing that targeting women, not just men, with extension services enhances the adoption of agricultural technologies. In a study conducted among dual households in the eastern part of the country, Fisher and Carr (2015) note that land tenure systems, credit access, and providing women with agricultural information enhance the uptake of improved maize varieties. Furthermore, Pan et al. (2018) find significant positive effects on adopting low-cost recommended agronomic practices and inputs by households, and on household food security, when women model farmers facilitate training and provide access to hybrid maize seed, particularly for fellow women smallholder farmers.

#### *4.2.2 Banana production in Uganda*

Uganda is the leading producer of the East African highland banana also known as the green cooking banana in East and Central Africa. The crop cultivated by one in every two households in the country (UBOS, 2020), is a major source of food and income for millions of smallholder households (Mbabazi et al., 2021), and it accounts for 17 percent of the daily caloric needs of the population (Fiedler et al., 2013). The banana plant offers significant environmental benefits in most farming systems, such as reducing soil erosion on steep slopes, maintaining soil structure, and providing shade for other intercrops like beans, groundnuts, and coffee (Wairegi et al., 2010). Various parts of the crop can be used for domestic and industrial purposes. For instance, leaves and pseudo-stems are essential for maintaining soil moisture and improving soil fertility; leaf-sheaths and fibres for thatching, making handicrafts and clothing; leaves for wrapping food while steaming it; whereas peels and pseudo-stems are valuable livestock fodder (Ochola et al., 2013).

Despite the importance of the banana crop, yields are inherently low due to pests and diseases and abiotic constraints such as drought stress and insufficient soil nutrients (Mbabazi et al., 2021; Van Asten et al., 2011; Wairegi et al., 2010). Poor soil fertility is a persistent problem due to continuous production without adequate nutrient replenishment and the removal of nutrients through increased banana sales

(Wairegi et al., 2010) and the long dry spells leading to moisture stress compound low productivity (Van Asten et al., 2011). Various soil fertility and water conservation measures, such as manure and mulch application and drainage channels known as trenches, are recommended to address declining soil fertility and water shortages (Bationo et al., 2007; Kihara et al., 2022).

Manure supplies essential nutrients and increases soil organic matter, which improves soil structure, enhances aeration, boosts water infiltration, and increases available water capacity (Bationo et al., 2007). Mulching suppresses weeds, and enhances soil water infiltration and conservation, eventually decomposing to provide soil nutrients, resulting in higher yields (Kihara et al., 2022). Trenches facilitate rainwater infiltration into the soil and its storage for later use by the crop, thus mitigating growth and yield penalties due to drought stress (Van Asten et al., 2011). These three technologies are complementary, and their combined use has been documented to increase productivity substantially (Bationo et al., 2007; Kihara et al., 2022). A study conducted in the banana systems in Uganda observed that farmers are keen to apply technologies that offer multiple benefits such as enhanced productivity, soil fertility improvement, and water conservation, but are constrained largely by insufficient knowledge and resources (Ochola et al., 2013). Thus, providing farmers with relevant agricultural information and access to resources is bound to boost the uptake of technologies and increase productivity.

#### *4.2.3 Study design and theory of change*

Like many other commercial crops, the banana value chain is dominated by men. Production is primarily controlled by men, who own and manage most of the plantations and control the sales (Ajambo et al., 2020). Generally, men have a stronger voice in intrahousehold agricultural decision-making, particularly when a crop is marketed, partly due to gender norms that assign them the roles of breadwinner and household head (Lecoutere & Jassogne, 2019; Lodin et al., 2012). The men's banana plantations are generally larger than the few owned by women (Ochola et al., 2013). Women greatly contribute to farm labour, even when they do not own banana plantations. Women predominantly do the weeding, men mostly dig trenches, while activities such as planting, de-trashing, and de-budding are jointly performed (Ajambo et al., 2020). Despite their involvement in agricultural production, women are rarely provided with extension services. This coupled with limited control over productive assets, difficulties in

accessing credit and farm inputs, and minimal involvement in decision-making, hinders the adoption of technologies even among dual households (Fisher & Carr, 2015; Lambrecht et al., 2016).

The banana agronomy extension-based campaign was a five-year initiative promoting agronomic technologies in Uganda from 2017 to 2021. The campaign was implemented through a randomized controlled trial and information was disseminated through various channels. The agronomic technologies promoted include manure application, mulching, and trenches. All farmers, including those in the control area, were exposed to information through radio talk shows. In addition to this audio channel, farmers in the treatment area received information through audio-visual channels such as video-drama shows and lecture trainings, as well as hands-on approaches including demonstration trials and farmer field days. The intervention aimed to foster the adoption of agronomic practices to boost banana productivity, increase household incomes, reduce poverty, and enhance food security among smallholders. Previous research in the country found that combining traditional extension methods, such as lectures and demonstrations, with video, while specifically targeting women, not only improved their knowledge but also effectively closed the gender knowledge gap (Cai et al., 2014). Our intervention deliberately targeted women as role models and participants and various measures were instituted to enable their involvement.

During the 12-week radio campaign, a team of three people constituted the panel that aired the radio talk show each week. The panel members were selected from the various implementing teams, for example, researchers, local leaders, sub-county extension officers, district production office staff, and farmers. Each week, a different set of people constituted the panel, but as a rule of thumb, at least one of the three members was a woman. The video drama was enacted by farmers within the treatment sites and about half of the cast were women. The scenes involved spouses working together in their plantations, while implementing the recommended practices and emphasis was placed on joint decision-making within the household regarding aspects such as agriculture, sales, credit, and the use of income. The drama portrayed households where spouses worked jointly, attended training sessions together, adopted the recommended technologies, and made joint decisions as prosperous.

Furthermore, most campaign activities were conducted in the afternoons and the radio talk shows were broadcast in the evenings to enable the involvement of women farmers. The in-person training sessions were decentralized and performed at the Parish level instead of the Subcounty to increase proximity. The campaign also established demonstration trials and women hosted at least 40% of these to increase participation. Such measures as changing the time or place of meetings, involving women as model farmers, and instituting quotas necessitating a given percentage of female participants have been reported to alleviate gender-based constraints to participation in activities (Johnson et al., 2018). As part of our intervention, we also supported the formation of gender-inclusive groups for knowledge sharing, collective marketing, saving, and access to credit. Such initiatives empower women, and they are precursors for increased uptake of agricultural technologies and improved welfare among rural households (J. H. L. Malapit et al., 2015; Sraboni et al., 2014).

Empowerment is the process through which individuals, particularly women, gain the ability to make and act on important life choices that were previously unavailable to them (Kabeer, 1999). This ability is built on three key components: access to resources such as information, assets, and social capital; agency, which is the capacity to act on decisions; and achievement, which includes social and economic outcomes like income and well-being (Lecoutere et al., 2023). Women's empowerment refers to their enhanced ability to make decisions and act upon them both individually and collectively within the household (Johnson et al., 2018).

Table 4.1 Empowerment Domains, Indicators, and Adequacy Definitions for the A-WEAI.

| Domain     | Indicator                        | Adequacy  | Weight |
|------------|----------------------------------|---|--------|
| Production | Input in productive decisions    | Sole/joint participation in at least one production decision related to food crops, cash crops, livestock, or fishing | 1/5    |
| Resources  | Asset ownership                  | Sole/joint ownership of at least one major asset  | 2/15   |
|            | Access to and decision on credit | Sole/joint control or participation in decision-making on credit from at least 1 source                               | 1/15   |
| Income     | Control over the use of income   | Sole/joint control over income from at least one source i.e., food crops, cash crops, livestock, or fishing           | 1/5    |
| Leadership | Group membership                 | Active membership in at least one formal or informal group  | 1/5    |
| Time       | Workload                         | Spend 10.5 hours or less on paid and unpaid work  | 1/5    |

Source: Malapit et al. (2017).

The Women's Empowerment in Agriculture Index (WEAI) is a broadly used standardized measure of women's empowerment. The WEAI is robust, inclusive, multidimensional, comparable over time and space, and able to measure the impact of agricultural interventions on women's empowerment (Alkire et al., 2013). We utilize the Abbreviated Women's Empowerment in Agriculture Index (A-WEAI), a summarised version of the WEAI to measure empowerment (H. Malapit et al., 2017). The A-WEAI is a survey-based index that measures women's empowerment, agency, and inclusion in agriculture, based on their achievement adequacy scores in five agricultural domains, namely production, resources, income, leadership, and time (Alkire et al., 2013; H. Malapit et al., 2017). Each domain indicator measures whether an individual respondent has achieved adequacy, with each domain receiving equal weight when the indicators are aggregated as shown in Table 4.1.

Failure to achieve adequacy in at least four out of the five domains indicates disempowerment. A study conducted in Uganda found that 56.7% of women in rural dual households are disempowered, citing heavy workloads and lack of control over resources as the key contributors to women's disempowerment (Alkire et al., 2013). Ugandan women's work burden and limited decision-making power within households are deeply rooted in gender norms and roles (Lecoutere et al., 2023). Recent research in banana farming systems asserts that inequalities stemming from inherent gender and social norms related to access to, and decision-making over productive resources limit particularly women farmers' ability to effectively engage in activities that could lead to the adoption of recommended technologies (Nkengla-Asi et al., 2020). Agricultural technology promotion interventions may influence household gender relations and contribute to women's empowerment. Additionally, the use of Information Communication Technology (ICT) in disseminating agricultural information has been shown to empower rural women by increasing their knowledge, leading to higher adoption rates, and improved yields (Lecoutere et al., 2023).

Based on our interventions, we expect our campaign to positively influence women's empowerment in four domains namely: production, resources, income, and leadership. This will be achieved through the following domain indicators: increased input in productive decisions, greater access to and involvement in credit decisions, enhanced control over income, and increased group participation, respectively. The

impact on the time domain is likely to be mixed because increased labour support from their husbands and the adoption of labour-saving technologies such as mulching could substantially reduce women's workloads. Conversely, involving women in campaign activities and the adoption of multiple technologies might increase their workloads. Studies show that including women in agricultural programs and ensuring that they have equal access to information and other resources empowers them and facilitates the achievement of development objectives including the adoption of technologies and improved food security nutrition within their households (Ahmed et al., 2023; Lecoutere et al., 2023; Quisumbing et al., 2021).

#### 4.2.4 Study area

We implemented the extension-based campaign through a field experiment in six major banana-growing districts namely Nakaseke and Luwero in the central region, Kabarole and Bunyangabu in mid-western, and Rugando and Isingiro and Rwampara in south-western Uganda. One district from each region was randomly selected as the treatment group (i.e., Nakaseke, Bunyangabo, and Isingiro) and the other as the control. In each treatment district, one sub-county was randomly selected as the treatment unit, namely Nakaseke sub-county in Nakaseke district, Rwimi in Bunyangabo, and Birere in Isingiro. One subcounty from each control district was randomly selected as the counterfactual. The control group consisted of Makulubita sub-county in Luwero, Busoro in Kabarole, and Rugando in Rwampara district. Figure 4.1 is a map of Uganda showing the study areas.

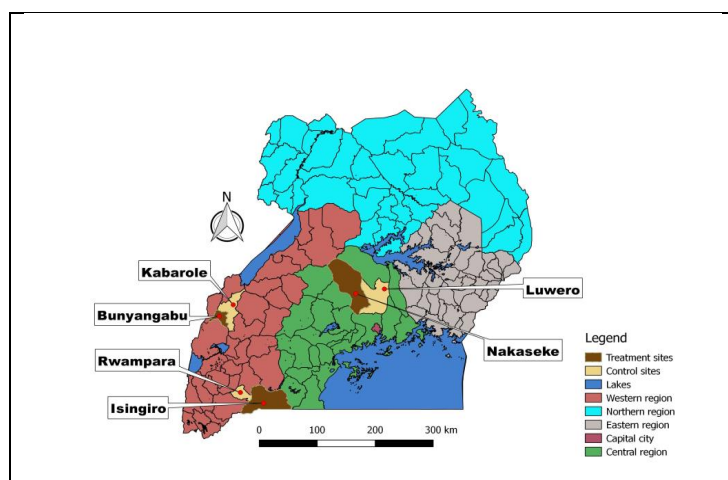


Figure 4.1: Map showing the study area.

### 4.3 Data, descriptives, and attrition

We conducted a baseline survey before the onset of the intervention in 2017. Using a structured questionnaire, we collected information regarding household demographics, social, and economic characteristics, access to agricultural extension and sources of agricultural information, banana production, and the agronomic practices employed. Data was collected from 471 households of which 359 are dual. In 2022, we conducted the endline survey collecting data on the same aspects targeting the same households. We only managed to interview respondents from 430 households, 305 of which are dual. Since several of our indices require data from men and women within the same household, we focus our analysis on dual households. Thus, our target baseline sample consists of 359 dual-adult households, but we were only able to interview respondents from 305 of these households during the endline survey, leading to a 15% attrition rate.

Due to limited resources, we collected data on women's empowerment during the endline survey. We utilized the A-WEAI tool developed by the International Food Policy Research Institute (IFPRI). The A-WEAI has been widely used to assess women's empowerment globally. The A-WEAI questionnaire was administered separately to the primary male and female decision-makers in a dual household. We collected responses from 272 women and 237 men. In some households, we only interviewed one spouse in cases where the other was not available or declined.

Table 4.2 presents the descriptive statistics and covariate balancing tests that assess the effectiveness of the randomization procedure. Besides the land owned, the rest of the baseline attributes are similar across the treatment and control groups. Hence, randomization bias is not a major concern in our study. The women in the sample are aged 41 years and they are about seven years younger than their husbands. The men acquired primary level education (7 years), whereas on average their wives spent six years in school. There are about five members in each household, and this is in line with the national average (UBOS, 2021). The households in the treatment group own about seven acres of land whereas those in the control group own about 5 acres. At baseline, the sampled households were utilizing at least one practice on average out of the three practices considered namely mulch, manure, and trenches.

Table 4.2 Descriptives and Balance Tests

|                           | Pooled sample |          | Treatment group |          | Control group |          | Mean difference |
|---------------------------|---------------|----------|-----------------|----------|---------------|----------|-----------------|
|                           | Mean          | SD       | Mean            | SD       | Mean          | SD       | Treated-Control |
| <u>Control variables</u>  |               |          |                 |          |               |          |                 |
| Woman's age (years)       | 40.747        | (13.040) | 41.520          | (12.379) | 39.795        | (13.789) | 1.725           |
| Woman's education (years) | 5.780         | (3.833)  | 5.773           | (3.881)  | 5.789         | (3.786)  | -0.016          |
| Man's age (years)         | 48.067        | (14.515) | 47.909          | (14.275) | 48.261        | (14.847) | -0.352          |
| Man's education (years)   | 7.123         | (4.150)  | 7.131           | (4.078)  | 7.112         | (4.249)  | 0.020           |
| Household size (number)   | 5.089         | (2.108)  | 5.205           | (2.102)  | 4.946         | (2.112)  | 0.259           |
| Land owned (acres)        | 6.280         | (11.150) | 7.333           | (11.958) | 4.986         | (9.953)  | 2.347**         |
| TLU                       | 1.627         | (7.076)  | 1.983           | (9.275)  | 1.188         | (2.397)  | 0.795           |
| Wealth index              | 0.151         | (1.629)  | 0.095           | (1.564)  | 0.219         | (1.709)  | -0.124          |
| <u>Outcome variables</u>  |               |          |                 |          |               |          |                 |
| Mulch adoption (1=Yes)    | 0.474         | (0.500)  | 0.485           | (0.501)  | 0.460         | (0.500)  | 0.025           |
| Manure adoption (1=Yes)   | 0.460         | (0.499)  | 0.439           | (0.498)  | 0.484         | (0.501)  | -0.045          |
| Trenches adoption (1=Yes) | 0.454         | (0.499)  | 0.455           | (0.499)  | 0.453         | (0.499)  | 0.001           |
| Package adoption (number) | 1.387         | (0.970)  | 1.379           | (0.941)  | 1.398         | (1.008)  | -0.019          |
| Observations              | 359           |          | 198             |          | 161           |          |                 |

SD is the standard deviation, with values in parentheses. \*, \*\*, \*\*\* denote significant difference is at 10%, 5% and 1% level, respectively.

Table 4.3 Attrition correlates

|                                   | Coefficient | Standard error | p-value |
|-----------------------------------|-------------|----------------|---------|
| Treatment (1=Treated, 0=Control)  | -0.054      | 0.046          | 0.298   |
| Woman's age (years)               | -0.002      | 0.002          | 0.171   |
| Woman's education (years)         | -0.006      | 0.005          | 0.279   |
| Man's age (years)                 | 0.001       | 0.002          | 0.593   |
| Man's education (years)           | -0.008      | 0.007          | 0.318   |
| Household size                    | -0.013      | 0.014          | 0.400   |
| Land owned (acres)                | 0.003       | 0.003          | 0.321   |
| Tropical Livestock Units (TLU)    | 0.005       | 0.001          | 0.018** |
| Wealth index                      | 0.019       | 0.021          | 0.389   |
| Constant                          | 0.353       | 0.072          | 0.004   |
| Number of observations            | 359         |                |         |
| <i>Test of joint significance</i> |             |                |         |
| F-statistic: Treatment            | 1.35        |                |         |
| p-value                           | 0.298       |                |         |

\*, \*\*, \*\*\* denote that the difference is significant at 10%, 5% and 1% level, respectively.

Table 4.3 reports how attrition is correlated with treatment and the baseline covariates. Attrition was not significantly correlated with treatment and the F test with a p-value of 0.298 implies that we cannot reject the null hypothesis that, jointly, attrition does not differ across the treatment group and the control group. Considering the baseline covariates, attrition increases with tropical livestock units, but the magnitude is small. Attrition is not significantly associated with any other selected baseline covariates.

## 4.4 Methodology

### 4.4.1 Empirical specification

Our impact assessment takes advantage of the RCT design of the intervention. The randomised assignment of households to treatment and control groups helps to reduce the observable and unobservable differences across these groups at baseline. Since our empowerment outcomes of interest were collected only at endline, our estimation relies on single-difference estimates, following Quisumbing et al. (2021). The specification used to assess the single-difference impact of the treatment relative to the control is described in equation (1):

$$E_i = \beta_0 + \beta_1 T_i + \beta_2 X_i + \beta_3 L_i + \mu_i \dots \dots \dots (1)$$

where  $E_i$  is a measure of empowerment for household  $i$ ,  $T_i$  is the treatment variable which is equal to 1 if the household belongs to the treatment group and 0 for the control group.  $\beta_1$  is the single-difference impact estimator for the treatment,  $X_i$  is a vector of control variables for baseline covariates,  $\beta_2$  represents their associated coefficients,  $L_i$  are location-fixed effects and  $\beta_3$  represents their corresponding coefficients and  $\mu_i$  is the error term. We run separate regressions for outcomes constructed separately for men and women. Standard errors are clustered at the subcounty level, which is the level at which the randomization was conducted.

To analyse the influence of the treatment and women's empowerment on the adoption of agricultural technologies, we regress the changes in the household's adoption of mulching, manure, trenches, or a package of the three technologies between the endline and baseline on the treatment and women's empowerment indicators as shown in equation (2):

$$Y_{i,t2} - Y_{i,t1} = \beta_0 + \beta_1 T_i + \beta_2 X_i + \beta_3 L_i + \beta_4 E_i + v_i \dots \dots \dots (2)$$

Where  $Y_{i,t2}$  and  $Y_{i,t1}$  correspond to the adoption of the technology at the endline and baseline respectively,  $E_i$  is a measure of women's empowerment for household  $i$ , at endline,  $v_i$  is the error term, and the other terms are as described in Equation 1. Based on our intervention and theory of change, we use the following sub-indicators of women's empowerment that constitute the A-WEAI: participation in agricultural decisions (whether the woman participates in two or more decisions), number of groups, credit, and income decisions that the woman is involved in. We consider membership in various groups including farmers', self-help, savings and credit, civic, and religious groups. The number of income decisions the woman is involved in is based on the number of income sources for the household. The same applies to the credit decisions.

Statistical analyses that involve testing multiple outcomes simultaneously from the same dataset are prone to the "type 1 error" of rejecting the null hypothesis when it is true. We adjust for multiple hypothesis testing by controlling the false discovery rate (FDR) and constructing sharpened q-values following Anderson (2008). We present both unadjusted p-values and sharpened q-values and consider the significance of the results based on the latter.

## 4.5 Results and discussion

### 4.5.1 *Impact of the campaign on men's and women's aggregate empowerment*

To determine aggregate empowerment for men and women, we use the censored empowerment score, the number of adequacies, and the empowerment gap. These measures are obtained from the A-WEAI and they are commonly used indicators in empowerment studies (J. H. L. Malapit et al., 2015; Quisumbing et al., 2021). The censored empowerment score is the weighted average of achievements in the 6 indicators if the respondent is disempowered, and it is equal to one if she is empowered. Censored empowerment scores are used for consistency with the construction of the WEAI and other Alkire-Foster indices. The number of adequacies represents the number of sub-domains in which an individual achieves adequacy or is empowered, and it ranges from 0-6. The empowerment gap refers to the average percentage shortfall that a woman without parity<sup>9</sup> experiences relative to the male in her

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<sup>9</sup> A woman enjoys gender parity if she is empowered or when her empowerment score is equal to or greater than the empowerment score of the primary male in her household (Alkire et al., 2013). Thus, the empowerment gap is

household. The impact estimates of the campaign on the aggregate empowerment of men and women are presented in Table 4.4. The intervention had a significant impact on empowerment for both men and women, though it was higher among the former. The campaign also significantly reduced the empowerment gap between men and women in the same household, hence it improved gender parity.

Table 4.4 Impact of the campaign on aggregate men's and women's empowerment scores

|              | <u>Empowerment score (censored)</u> |                     | <u>Number of adequacies</u> |                     | <u>Empowerment gap<sup>a</sup></u> |
|--------------|-------------------------------------|---------------------|-----------------------------|---------------------|------------------------------------|
|              | Men                                 | Women               | Men                         | Women               | Household                          |
| Treatment    | 0.124***<br>(0.005)                 | 0.023***<br>(0.003) | 0.794***<br>(0.030)         | 0.142***<br>(0.021) | -0.026***<br>(0.004)               |
| Observations | 237                                 | 272                 | 237                         | 272                 | 204                                |
| R-squared    | 0.156                               | 0.155               | 0.153                       | 0.087               | 0.062                              |

Standard errors clustered at the subcounty level are shown in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Treatment estimates control for individual's age and level of education, household size, land owned, TLU, wealth index, and district fixed effects. <sup>a</sup>Treatment estimates control for women's age and education and the other household controls listed.

#### 4.5.2 Impact of the campaign intervention on men's and women's empowerment sub-domains

Table 4.5 presents the results of the impact of the campaign on the sub-domains of men's and women's empowerment. There was a significant increase in participation in agricultural, income, and credit decisions and group involvement among the men and women in the treatment group compared to their counterparts in the control. Although the men in the treatment sites spent an hour more daily working on their farms compared to those in the control, overall, they spent less time on work than those in the control group. The women in the treatment group had significantly greater workloads than those in the control group. They spent two hours more working on the farm and overall, their daily working hours exceeded those of their counterparts in the control group by one hour. The increased farm workload could be due to increased management levels of the plantations and uptake of the recommended practices, whereas the overall increased workload could be attributed to the increased involvement in campaign activities. A previous study in Uganda found that women's workload was a major contributor to their disempowerment (Alkire et al., 2013). Women's work burden stems from gender roles that assign

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zero if the household enjoys gender parity. Otherwise, the gap equals the difference in the male and female aggregate empowerment scores.

the majority of caregiving and household tasks to women, alongside their responsibilities in farming (Lodin et al., 2012). Moreover, enhancing women's participation in agricultural development projects has been associated with an increase in their workload in both productive and domestic responsibilities (Johnson et al., 2018; Quisumbing et al., 2021), a concern that needs to be addressed. Promoting initiatives that reduce women's work burden such as decentralizing sources of clean water, availing labour-saving technologies both on-farm and off-farm, and promoting initiatives that advocate for men to support their spouses could substantially reduce women's workload.

Table 4.5 Impact of the campaign on men's and women's empowerment sub-domains/indicators

|                | Participation in<br>Agric decisions       | No. of<br>Credit<br>decisions             | No. of<br>Income<br>decisions             | No. of<br>Groups                          | Total work<br>hrs/day                      | Total farm<br>hrs/day                     |
|----------------|---|---|---|---|--|---|
| Panel A: Men   |   |   |   |   |  |   |
| Treatment      | 0.234***<br>(0.012)<br>{0.000}<br>[0.001] | 0.074***<br>(0.014)<br>{0.004}<br>[0.002] | 0.260***<br>(0.022)<br>{0.000}<br>[0.001] | 1.122***<br>(0.044)<br>{0.000}<br>[0.001] | -0.729***<br>(0.082)<br>{0.000}<br>[0.001] | 1.182***<br>(0.119)<br>{0.000}<br>[0.001] |
| Observations   | 237                                       | 237                                       | 237                                       | 237                                       | 237  | 237                                       |
| R-squared      | 0.044                                     | 0.139                                     | 0.004                                     | 0.265                                     | 0.204                                      | 0.045                                     |
| Panel B: Women |   |   |   |   |  |   |
| Treatment      | 0.257***<br>(0.021)<br>{0.000}<br>[0.001] | 0.152***<br>(0.029)<br>{0.003}<br>[0.002] | 0.296***<br>(0.027)<br>{0.000}<br>[0.001] | 0.571***<br>(0.031)<br>{0.000}<br>[0.001] | 0.818***<br>(0.150)<br>{0.003}<br>[0.002]  | 1.936***<br>(0.099)<br>{0.000}<br>[0.001] |
| Observations   | 272                                       | 272                                       | 272                                       | 272                                       | 272  | 272                                       |
| R-squared      | 0.072                                     | 0.066                                     | 0.086                                     | 0.191                                     | 0.143                                      | 0.130                                     |

Standard errors clustered at the subcounty level are shown in parentheses. p-values in curly {} brackets, sharpened q-values are in square [] brackets. \*\*\*, \*\*, \* represent significance at 1%, 5% and 10%, respectively. Treatment estimates control for individual's age and level of education, household size, land owned, TLU, wealth index, and district fixed effects.

#### 4.5.3 *Impact of the campaign and women's empowerment on the adoption of technologies*

The campaign intervention positively and significantly impacted the adoption of mulching, manure, trenches, and the combined package as shown in Table 4.6. These findings are in line with previous studies that reveal that the provision of information to both men and women increases the uptake of agricultural technologies (Kondylis et al., 2016; Lambrecht et al., 2016). For example, Lambrecht et al. (2016) note that joint participation of men co-heads and women co-heads in agricultural training sessions enhances the adoption of integrated soil fertility and management practices in the Democratic Republic

of Congo, while Kondylis et al. (2016) find a positive effect on awareness and adoption of sustainable land management practices among female farmers when they provide them with information.

Table 4.6 Impact of the campaign and women's empowerment on the adoption of technologies

|                             | Participation<br>in Agric<br>decisions    | No. of Credit<br>decisions                | No. of Income<br>decisions                | No. of<br>Groups                          |
|-----------------------------|---|---|---|---|
| <b>Adoption of mulching</b> |   |   |   |   |
| Treatment                   | 0.266***<br>(0.045)<br>{0.003}<br>[0.002] | 0.307***<br>(0.031)<br>{0.000}<br>[0.001] | 0.282***<br>(0.046)<br>{0.002}<br>[0.003] | 0.253***<br>(0.040)<br>{0.001}<br>[0.002] |
| Empowerment sub-domain      | 0.196**<br>(0.078)<br>{0.053}<br>[0.046]  | 0.053*<br>(0.024)<br>{0.075}<br>[0.055]   | 0.113*<br>(0.056)<br>{0.098}<br>[0.063]   | 0.109**<br>(0.032)<br>{0.018}<br>[0.018]  |
| <b>Adoption of manure</b>   |   |   |   |   |
| Treatment                   | 0.232***<br>(0.021)<br>{0.000}<br>[0.001] | 0.233***<br>(0.019)<br>{0.000}<br>[0.001] | 0.222***<br>(0.031)<br>{0.001}<br>[0.002] | 0.206***<br>(0.022)<br>{0.000}<br>[0.001] |
| Empowerment sub-domain      | 0.008<br>(0.057)<br>{0.901}<br>[0.227]    | 0.005<br>(0.015)<br>{0.736}<br>[0.227]    | 0.041<br>(0.045)<br>{0.400}<br>[0.149]    | 0.049<br>(0.031)<br>{0.172}<br>[0.102]    |
| <b>Adoption of Trenches</b> |   |   |   |   |
| Treatment                   | 0.354***<br>(0.011)<br>{0.000}<br>[0.001] | 0.353***<br>(0.022)<br>{0.000}<br>[0.001] | 0.356***<br>(0.019)<br>{0.000}<br>[0.001] | 0.357***<br>(0.024)<br>{0.000}<br>[0.001] |
| Empowerment sub-domain      | 0.013<br>(0.073)<br>{0.864}<br>[0.227]    | 0.034*<br>(0.015)<br>{0.068}<br>[0.054]   | 0.006<br>(0.029)<br>{0.851}<br>[0.227]    | 0.002<br>(0.016)<br>{0.914}<br>[0.227]    |
| <b>Adoption of Package</b>  |   |   |   |   |
| Treatment                   | 0.852***<br>(0.060)<br>{0.000}<br>[0.001] | 0.893***<br>(0.051)<br>{0.000}<br>[0.001] | 0.860***<br>(0.072)<br>{0.000}<br>[0.001] | 0.816***<br>(0.067)<br>{0.000}<br>[0.001] |
| Empowerment sub-domain      | 0.217*<br>(0.101)<br>{0.084}<br>[0.060]   | 0.093**<br>(0.029)<br>{0.024}<br>[0.023]  | 0.159*<br>(0.077)<br>{0.093}<br>[0.062]   | 0.161*<br>(0.070)<br>{0.071}<br>[0.095]   |

Standard errors clustered at the subcounty level in parentheses. p-values in curly {} brackets, sharpened q-values are in square [] brackets. \*, \*\*, \*\*\* denote that the difference is significant at 10%, 5% and 1% level, respectively. N=272

Women's participation in agricultural, credit, and income decisions and group involvement influence the adoption of the technologies. These aspects of empowerment are associated with improved

household welfare. For instance, Malapit et al. (2015) observe that women's group membership, control over income, reduced workload, and overall empowerment are positively associated with better maternal nutrition, while control over income is associated with better well-being of their children. All the women's empowerment domains considered in our study positively influence the adoption of mulching, although participation in agricultural decisions and group membership have the most significant effects. Empowered women adopt mulching probably because it benefits them directly, since it reduces the time they spend weeding. Women predominantly weed (Ajambo et al., 2020), and applying mulch suppresses weeds. Lecoutere et al. (2023) observe that women who are provided with information and participate in agricultural decisions tend to adopt practices related to weeding, which implies that women find it easier to adopt practices that align more closely with existing cultural norms and customs in agriculture.

The results also show that households with empowered women adopt the package of the three combined practices. The effect of women's involvement in credit decisions on the adoption of the package is significant at 5%. Implementing the three technologies together requires resources that may not be readily available, hence access to credit facilitates increased uptake. Previous related research in the country shows that access to information and credit influence women and men farmers' uptake of improved technologies (Fisher & Carr, 2015). During the training sessions in our study, the synergistic benefits of adopting the technologies in tandem were emphasized, a likely precursor for the farmers' decisions to adopt the package. Similarly, Lambrecht et al. (2016) found that joint participation of women and men in agricultural training sessions led to higher adoption rates of improved legume varieties, row planting, and mineral fertilizers.

The involvement of women in credit decisions influences the adoption of trenches though the effect is weak. Digging trenches is a male-dominated activity, because it requires manual labour. Possibly, women in dual households who are involved in credit decisions may hire labour to dig the trenches. None of the sub-indicators of empowerment significantly impacted the adoption of manure.

## 4.6 Conclusion

The low adoption of agricultural technologies in Sub-Saharan Africa has been attributed to the lack of access to information. The provision of extension services is largely male-dominated and typically targets male recipients. Some initiatives have targeted women, and they have observed increased technology adoption rates. However, women face barriers embedded in the cultural norms and beliefs that hinder the sustainable adoption of technologies. Recent research advocates for initiatives that extend beyond simply providing information to women, but also actively promote their empowerment. This calls for addressing other constraints such as women's limited access to financial and productive resources, and gender-responsive agricultural technology, along with gender norms affecting their time use, mobility, and decision-making power in addition to information provision all of which are essential to fully unlock women's potential and reduce gender disparities in agriculture (Ahmed et al., 2023; Lecoutere et al., 2023; J. H. L. Malapit et al., 2015).

In this study we disseminated information through multiple channels: radio, video, lecture trainings, farmer field days, and demonstration trials. The technologies promoted comprise mulching, manure, and trenches. Deliberate efforts were made to enable women's involvement in the campaign, empower them, and enhance the uptake of the technologies. These initiatives include decentralizing campaign activities at the parishes to ensure proximity to the venues, conducting activities in the afternoons, and actively involving the women in dissemination such as the radio talk shows, video drama, and as hosts of the demonstration trials. We also supported the formation of gender-inclusive groups for knowledge sharing, collective marketing, saving, and access to credit.

Our findings show that the campaign had a positive and significant impact on both men's and women's aggregate empowerment. The men and women in the treatment group achieved adequacy in more empowerment domains than those in the control group. Furthermore, among the households in the treatment sites, the empowerment gap between the primary male decision-maker and the primary female decision-maker was significantly reduced as a result of the intervention. This implies that more households in the treatment group enjoyed gender parity than those in the control group. Additionally, the campaign had a significant impact on the empowerment sub-domains outlined in our theory of

change. Both women and men within the treatment group increasingly participated in agricultural, credit, and income decisions and were involved in more groups than their counterparts in the control group. The results also revealed that the women in the treatment group spent on average two more hours daily doing farmwork and overall spent more time working than those in the control. Enhancing women's participation in agricultural development projects has been associated with an increase in their workload in both productive and domestic responsibilities (Johnson et al., 2018; Quisumbing et al., 2021), a concern that needs to be addressed.

Our campaign significantly influenced the adoption of mulching, manure trenches, and the combined package. Women's empowerment—evident through their participation in agricultural, credit, and income decisions, as well as group involvement—had a mediating effect on the adoption of these technologies. These aspects of empowerment are associated with improved household welfare (J. H. L. Malapit et al., 2015). Our results show that households with empowered women adopt practices that align with prevailing norms and customs in agriculture and benefit them directly like mulch that reduces the time they spend weeding. Furthermore, women's empowerment also significantly influenced the uptake of the package of the three technologies.

Our study results have multifaceted policy implications. While specific to our study context and country, these recommendations may still support efforts to reform extension policy and practice in other settings and countries. First, the provision of extension services should not only target men, but involve their spouses as well. Although directly providing information to women is highly beneficial, incorporating initiatives that not only enhance their agricultural knowledge but also facilitate their autonomy in decision-making and access to financial and productive resources will sustainably increase the adoption of recommended practices and ultimately improve productivity. This approach underscores the need for intensive gender-transformative methods rather than just gender-sensitive extension reforms. Examples of proven gender-transformative approaches include household methodologies that influence intrahousehold gender relations and decision-making by engaging both women and men in programs focused on agriculture, extension, and nutrition (Ahmed et al., 2023; Lambrecht et al., 2016; Quisumbing et al., 2021).

Second, our results indicate that, despite the welfare benefits, involving women in agricultural development projects has led to an increase in their workload, in both productive and domestic duties. This concern has also been observed in other studies (Johnson et al., 2018; Quisumbing et al., 2021) and may be addressed through holistic interventions that not only lighten the physical burden on women, but also increase their agency and economic empowerment. Such initiatives include farm and household labour-saving technologies (such as farm implements, fuel-efficient stoves, etc.), promoting shared household and farming responsibilities through gender-sensitization programs, and establishing supportive social infrastructure such as child-care facilities (Doss et al., 2015; Kieran et al., 2015). Through these strategies, women's workload can be reduced, promoting empowerment and addressing the structural barriers that contribute to their disempowerment.

## 4.7 References

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## CHAPTER 5

### Smallholder Household Resilience to Food Insecurity amidst Climate Change and COVID-19-induced Shocks: Evidence from Uganda

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#### Abstract

The COVID-19 pandemic and the measures instituted to curb its spread had devastating effects on smallholder farmers' livelihoods in many developing countries, particularly those in Sub-Saharan Africa which were already grappling with the impact of climate change. In the absence of relief and social protection, smallholders had to bank on their resilience capacity to cope with multiple shocks. In this study, we use three waves of household panel data from Uganda, collected before, during, and after the pandemic, to analyse the shocks and coping strategies that smallholders employed amidst the pandemic and the contributors to their resilience. We contribute to the growing demand for evidence-based interventions and strategies that enhance households' resilience to such shocks, by analysing the effect of an agronomy extension-based campaign implemented through a randomized controlled trial. We explore the impact of the campaign on household welfare and its buffering effect against the shocks threatening their food security. Using the resilience index measurement and analysis framework and the Difference-in-Differences approach, our study is among the few causal resilience evaluations based on experimental evidence. Our results show that asset ownership and social safety nets contributed greatly to household resilience. Health-related shocks had the most devastating impact on food security, heightened by mobility restrictions and detrimental coping strategies such as reduced health expenditure. Exposure to the campaign positively and significantly enhanced household welfare, particularly through improved dietary quality. Basic services, especially health facilities, tarmac roads, and agricultural markets, should be decentralized to enhance access and strengthen household resilience. Prioritizing investments in programs that decentralize extension services and improve the welfare and resilience of rural farming households is essential.

**Keywords:** COVID-19, climate-change, shocks, smallholders, resilience, food security, extension campaign

## 5.1 Introduction

The welfare of households in low-income countries is threatened by a myriad of natural and economic disasters such as global warming and climate change and more recently pandemics like the Corona Virus Disease 2019 (COVID-19) (Picchioni et al., 2021; Siche, 2020; Teklewold et al., 2017). Climate change is associated with shocks such as droughts, irregular rains, floods, hailstorms, landslides, and increased infestation of crop and livestock pests and diseases (Teklewold et al., 2017; Wichern et al., 2019). The COVID-19 pandemic resulted in multiple calamities ranging from health-related shocks involving illness and deaths of breadwinners and other household members, to several other shocks stemming from the measures instituted to curb its spread. These include economic shocks such as employment loss and reduction in earnings due to the closure of businesses, and mobility shocks due to travel bans that disrupted access to agricultural inputs and transportation of produce to markets (Kansiime et al., 2021). All these shocks tremendously affect agricultural production, income, and ultimately food and nutrition security (Béné et al., 2021; d'Errico et al., 2018; Kansiime et al., 2021) with more severe impacts in Sub-Saharan African countries that are largely dependent on agriculture and where many households are living below the poverty line without sufficient financial buffers or individual savings to maintain their food security (Béné et al., 2021).

The impacts of these recurrent shocks on food security have enhanced global interest in the resilience concept, which is increasingly recognized as a critical factor in food security planning at local, regional, national, and international levels (Béné et al., 2016; d'Errico et al., 2018). This growing focus stems from the premise that a household's level of resilience determines its ability to withstand or adapt to shocks (Alinovi et al., 2008). Resilience refers to the capacity of a system to withstand risks and shocks (d'Errico et al., 2018).

Uganda provides a compelling case for studying the impacts of climate change, and crises like the pandemic on agriculture and food security due to its heavy reliance on agriculture and its vulnerability to environmental, economic, and global disruptions. The agricultural sector contributes 24% to the country's Gross Domestic Product, 35% to its export earnings, and employs 68% of the labour force (World Bank, 2021). This heavy dependence on rain-fed agriculture makes smallholder farmers

particularly vulnerable to climate variability and shocks (Wichern et al., 2019). There are various agricultural practices such as integrated soil fertility and water conservation measures that mitigate the effects of climate change and enhance crop yields and food security (Abdulai & Huffman, 2014; Issahaku & Abdulai, 2019). However, adoption of these practices on-farm is low due to limited access to access to information (Abdulai, 2023; Aker, 2011). To address this, we implemented an extension-based campaign to disseminate agricultural information and promote technology adoption, aiming to enhance yields, incomes, and food security.

The vulnerabilities in Uganda's agricultural system were recently exacerbated by the global COVID-19 pandemic, which devastated economies and livelihoods, especially in developing countries with limited financial buffers for households and insufficient government resources to expand social protection schemes for the affected population (Béné et al., 2021; World Bank, 2021). Uganda faced pronounced impacts due to the extremely stringent control measures including two lockdowns with complete closure of all borders, schools, and businesses; night curfews; and banning of public/private transport and public gatherings (Kansiime et al., 2021; Tallio, 2021). These measures created significant economic stresses, with adverse consequences for food security and hunger, mostly attributed to reduced income and declining purchasing power (Kansiime et al., 2021). This highly affected the poorest and most vulnerable segments of the population, mainly the smallholder households, who could not access and work on their farms due to movement restrictions which caused labour shortages on farms and disrupted farmers' access to input and produce markets (Bitzer et al., 2024; Kansiime et al., 2021). Perishables mostly fruits and vegetables were more affected by the restrictions than storable products such as grains (Devereux et al., 2020), resulting in very low farm-gate prices offered by traders, especially in many parts of Uganda (Bitzer et al., 2024).

The government of Uganda intervened by giving relief measures in the form of a one-off food and cash supply, which were meagre and targeted a small segment of the population, predominantly informal workers in the peri-urban and urban areas (Tallio, 2021). Although farmers were presumably less affected, since they do not rely on the market to obtain most of their food, their earnings decreased because of the crisis and their food security and nutrition status worsened (Kansiime et al., 2021). No

specific social protection mechanism was deployed at the national level, leaving communities and individuals to cope on their own (Kansiime et al., 2021; Tallio, 2021). Worse still, generally in Uganda only three percent of the population receives social protection (World Bank, 2021). In the absence of the much-needed support, smallholders had to rely on their resilience capacity to cope with the effects of the pandemic (Bitzer et al., 2024).

Given these interconnected challenges of climate variability, agricultural dependence, and external shocks, Uganda provides an essential context to investigate the nexus between multiple shocks, food security, and resilience. This study explores the resilience of farming households in the face of climate change and COVID-19-related shocks and the impact of the campaign intervention in facilitating recovery. Specifically, it identifies the most significant shocks affecting food security, the coping strategies employed, key contributors to resilience, and the campaign's buffering effect. The findings show that health-related and mobility shocks had a significant negative impact on welfare, while social safety nets and asset ownership contributed greatly to household resilience. The campaign mitigated these effects, enhancing resilience capacity and significantly improving household food security.

The rest of paper is organised as follows. Section 5.2 describes the shocks, coping strategies, and resilience, while the study context, area, and data used are elaborated in Section 5.3. The methodology is described in Section 5.4, followed by the results and discussion in Section 5.5, and Section 5.6 concludes.

## **5.2 Shocks, coping strategies, and resilience**

### *5.2.1 Climate change and COVID-19-related shocks*

Shocks are sudden, disruptive events that affect individuals, households, communities, or economies, causing losses in well-being, income, or resources. They can be environmental (e.g., droughts, floods), economic (e.g., job losses, market disruptions), health-related (e.g., pandemics, disease outbreaks), or social (e.g., conflicts, displacement). Shocks may be idiosyncratic, affecting specific individuals/households, or covariate, impacting entire communities (d'Errico et al., 2018). The shocks arising from climate change include drought, floods, landslides, irregular rains, soil erosion, increased

levels of pests, and both animal and plant diseases all of which jeopardise household food security. Weather shocks, such as high temperatures, have caused substantial yield declines across Sub-Saharan Africa, with more drastic effects in countries like Uganda which have extremely low levels of irrigation (Sabiiti et al., 2018). The increasing frequency of extreme events, such as heavy rainfall and droughts, over the past decade, has severely disrupted the production of key crops including maize, beans, sorghum, cassava, coffee, and bananas that are essential for food security and livelihoods in Uganda, a trend likely to persist in the future (Wichern et al., 2019). Particularly, the yields of the cooking banana crop, a major staple in the country, are persistently low due to drought stress and moisture deficits (Sabiiti et al., 2018; Van Asten et al., 2011).

Like climate change, the COVID-19 pandemic is a natural disaster that has devastated livelihoods globally, particularly poor households. The eventualities of the pandemic include illness or death due to the virus, increase in agricultural input prices, low output prices, high transport costs, lack of market, labour shortage, loss of employment, reduced purchasing power, and change in diets (Béné et al., 2021; Kansiime et al., 2021). These outcomes negatively affect food and nutrition security directly or indirectly.

Households in shock-prone areas often face multiple shocks, which are generally more challenging to cope with than single shock events. Poor households, particularly in developing countries, frequently encounter several shocks concurrently (Béné et al., 2024). However, empirical analyses often focus on single or isolated shocks, paying limited attention to the effects of multiple shocks (e.g., Brück et al., 2019; Smith & Frankenberger, 2022), while those that explore many shocks primarily assess their direct impacts on welfare outcomes, giving less consideration to coping strategy choices (Béné et al., 2016; d'Errico et al., 2020).

### 5.2.2 *Coping strategies*

Literature is replete with the coping strategies that smallholder farmers employ to mitigate the effects of climate change shocks including early planting, crop diversification, and using drought-tolerant varieties (Sabiiti et al., 2018; Teklewold et al., 2017; Wichern et al., 2019). Despite the voluminous literature on the impact of COVID-19, there is still paucity of information on the coping strategies that

smallholder farmers employed and their resilience capacity in the face of the pandemic. An online rapid assessment study conducted in Uganda and Kenya revealed that during the early pandemic period, households relied on savings and changed dietary patterns by consuming less diverse diets, skipping meals, and reducing portions of food consumed, which was found to be detrimental to their food and nutrition security (Kansiime et al., 2021). This study largely excluded rural smallholder farmers who do not have access to online platforms. Little is known about the impact of the pandemic on the livelihoods of smallholders who constitute the biggest sector, more so those involved in producing highly perishable crops like bananas, and the mechanisms they employed to cope with the drastic pandemic effects, and their resilience capacity. Yet, such information is vital for guiding policy interventions for future outbreaks. A recent study by Bitzer et al. (2024) assessed the effect of the COVID-19 containment measures on the vulnerability and resilience of smallholder producers and small-scale market actors in Uganda and Kenya. However, this study utilised cross-sectional data, making it difficult to capture resilience, which is a dynamic concept that necessitates longitudinal analysis (Ansah et al., 2019; d’Errico et al., 2018).

### 5.2.3 *Household resilience*

The Food and Agricultural Organization (FAO) defines resilience as the capacity of a household to bounce back to a previous level of well-being, such as food security, after a shock (FAO, 2016). The household is the most suitable unit for resilience analysis because it is where the most important risk management decisions are made, both ex-ante and ex-post, including those influencing food security, such as selection of the income-generating activities to engage in, allocation of food and non-food consumption among household members, and the coping strategies to employ in case of shocks (d’Errico et al., 2018; FAO, 2016). Since many of the common shocks faced by farm households recur, the literature on coping and adaptation strategies indicates that farm households take definite or specific actions before, during, and after the occurrence of shocks (Ansah et al., 2019). Household dietary diversity score (HDDS) and food expenditure per capita assessed at different points in time, are among the most suitable indicators of well-being used in household resilience analysis (d’Errico et al., 2018). The characteristics of the broader system to which the household belongs need to be explicitly accounted

for in the analysis and, the period under consideration should be long enough to allow the household to recover and this usually necessitates an analytical timeframe spanning at least a year (d'Errico et al., 2018). The present study contributes to the literature by analysing the resilience of smallholder households over time (using panel data) to the effects of multiple shocks arising from the COVID-19 pandemic and climate change, on their food and nutrition security in Uganda.

### **5.3 The Study context, area, and data**

#### *5.3.1 Study context: The agronomy extension-based campaign*

The agronomy extension-based campaign was implemented under the banana agronomy project which was a 5-year initiative that was launched in 2017 in the major banana-growing regions in Uganda. The banana crop was selected because it is a major staple crop grown by more than half of the farm households in the country and a key source of income for smallholders (Kikulwe et al., 2019). Despite its importance, the crop was not yielding to its full potential due to pest and disease infestations, drought, moisture stress, and soil fertility issues (Van Asten et al., 2011). Farmers lacked access to information on crucial innovative practices to overcome production constraints (Ochola et al., 2013). Yet, access to agricultural information contributes to resilience directly and indirectly. Information access is a direct measure of resilience, and it has been used in previous empirical studies as a key component of adaptive capacity, one of the pillars of resilience (d'Errico et al., 2023; Lascano, 2020; Smith & Frankenberger, 2018). This implies that households with access to agricultural information are more likely to implement mitigation measures, enabling them to adapt more effectively during catastrophes such as prolonged droughts. Furthermore, empirical evidence shows that providing farmers with adequate information influences their decision to adopt agricultural technologies that significantly increase their yields and improve their food security levels (Abdulai, 2023; Van Campenhout et al., 2021). This impact of information access on food security highlights the indirect relationship between information accessibility and resilience, because food security is an outcome of resilience (d'Errico et al., 2018; Lascano, 2020) and it is commonly referred to as realised resilience in the literature (Smith & Frankenberger, 2018, 2022).

Relatedly, lack of information due to inadequate extension services is a major impediment to the adoption of improved agricultural practices by smallholder farmers (NPA, 2018; Abdulai, 2023), resulting in lower yields for many key crops including banana (Ochola et al., 2013) and subsequently food insecurity. Access to information enhances household welfare measures, such as food security, primarily through the adoption of agricultural technologies. In Uganda, the government is responsible for providing agricultural extension services, but the system is overstretched, with too few extension officers covering vast areas with limited resources (NPA, 2018). National statistics report a ratio of one extension officer per 2,500 farmers (UBOS, 2020). This shortage hinders the dissemination and adoption of agricultural technologies through public extension services (Benin et al., 2011), despite evidence that technology adoption enhances smallholder farmers' welfare by increasing yields and improving food security and nutrition (Van Campenhout et al., 2021). Development partners help to bridge the gap by implementing projects that provide farmers with information and knowledge, though such initiatives are not widespread (NPA, 2020).

The extension-based campaign disseminated agronomic information to farmers using multiple channels within a randomized controlled trial framework. All farmers, including those in the control group, received information through a 12-week radio talk show. In addition to this audio channel, farmers in the treatment group accessed information via audio-visual means, including video-drama screenings and lecture-style trainings, as well as hands-on approaches such as demonstration trials and farmer field days. The intervention aimed to promote the adoption of improved banana agronomic practices, thereby enhancing productivity, increasing household incomes, reducing poverty, and improving food security among smallholder households. Given farmers' varying access to and preferences for information sources, employing multiple dissemination channels is essential for broad outreach (Van Campenhout et al., 2021). Moreover, farmers are more likely to retain and apply knowledge when they can visualize and practice it rather than relying solely on hearing it (Van Campenhout et al., 2021).

The campaign facilitated the formation of gender-inclusive groups in the treatment sites to enhance knowledge sharing, collective marketing, savings, and access to credit. These groups boosted household resilience by increasing technology adoption, improving market access and bargaining power, and

providing credit, especially during crises. These groups were linked to traders and buyers, which eased market access and boosted sales. The campaign strengthened key resilience pillars, including access to basic services through better market opportunities, social safety nets via group membership and credit access, and adaptive capacity through access to information<sup>10</sup> and savings. Strengthening these pillars is expected to enhance the resilience and food security of participating households.

While various interventions in low-income countries aim to improve smallholders' welfare, there is limited evidence of their buffering effect against unprecedented crises that threaten the targeted households' resilience and food security. A study in Bangladesh conducted among households that were beneficiaries of a resilience-enhancing program investigated the extent to which their resilience capacities before the onset of a flood boosted their ability to maintain their food security amidst the shock (Smith & Frankenberger, 2018). Although the study provided insights into how such initiatives augment household resilience capacities and help mitigate the negative impacts of unprecedented shocks on their well-being, data limitations prevented causal inference on food security, making the findings exploratory and the evidence suggestive. A more recent study on the impact of a resilience-strengthening intervention in Ethiopia's drought-prone drylands represents one of the first causal resilience evaluations (Smith & Frankenberger, 2022). However, lacking a distinct control group, it relied on a quasi-experimental approach using the Difference-in-Difference Propensity Score Matching (DID-PSM) technique. The present study contributes to the literature by evaluating the impact of an agronomy extension-based campaign, implemented in an experimental setting in western Uganda, on smallholder welfare and its effectiveness in shielding households from climate change and COVID-19-induced shocks.

Our study adds several significant contributions to resilience literature by quantitatively assessing how resilience capacity enhanced household well-being during real-life shocks. Grounded in a comprehensive understanding of resilience determinants, this analysis provides valuable insights for

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<sup>10</sup> Although access to agricultural information has been used in the computation of the resilience index as a component of the adaptive capacity pillar in some previous studies (d'Errico et al., 2023; Lascano, 2020), we exclude it from our analysis to address potential endogeneity in our resilience indicator. Such exclusions have been made in some resilience studies (d'Errico et al., 2020).

designing effective interventions. As noted by d’Errico et al. (2018) and Smith & Frankenberger (2018), focusing on the entire spectrum of resilience capacities enables policymakers, planners, and other stakeholders to make more informed decisions.

Empirical evidence shows that access to agricultural information and extension services contributes to the resilience of farm households mainly through strengthening their adaptive capacity (d’Errico et al., 2023; Lascano, 2020), particularly through the adoption of agricultural technologies that enhance yields and food security (Pan et al., 2018). Previous studies that examined the impact of agricultural information dissemination interventions on household welfare did so without regard to resilience capacities. Yet, resilience capacities enable households to maintain their welfare, especially during unprecedented crises that are increasingly becoming rampant. By analysing the causal impact of the extension campaign on farm households’ resilience capacities and food security, this study provides evidence-based policy recommendations for analysts, policymakers, and other stakeholders implementing such interventions in this era of growing uncertainties.

Due to the travel and mobility restrictions imposed during the pandemic, most previous empirical research associated with resilience to COVID-19 shocks in Uganda was based on online surveys (e.g. Kansiime et al., 2021) which could bias selection to more educated or wealthier individuals who have access to smartphones, largely excluding farmers.

Furthermore, given the uncertain and volatile nature of shocks, they cannot easily be modelled into impact evaluations at the onset of implementing resilience-enhancing interventions. As a result, causal resilience evaluations, particularly in experimental settings, remain scarce, with related studies typically using quasi-experimental approaches (e.g., Smith & Frankenberger, 2022). Our study contributes to this largely unexplored field by assessing the impact of the extension campaign implemented through a randomized controlled trial on mitigating the adverse effects of climate change and the pandemic-related shocks, and its role in facilitating recovery for the participating households.

### 5.3.2 Selection of study area and farmers

The study was conducted in four of the major banana-growing districts in Uganda, Bunyangabu and Kabarole districts in the mid-western region and Isingiro and Rwampara districts in the south-west. In each region, one district was randomly assigned to the treatment group while the other served as the control. Within each district, one subcounty was selected as a study site. Rwimi subcounty in Bunyangabu district was the treatment site and Busoro subcounty in Kabarole district was the control site in the mid-western region. In the south-west, Birere subcounty in Isingiro district was the treatment site and Rugando subcounty in Rwampara district was the control site. Figure 5.1 shows the study area.

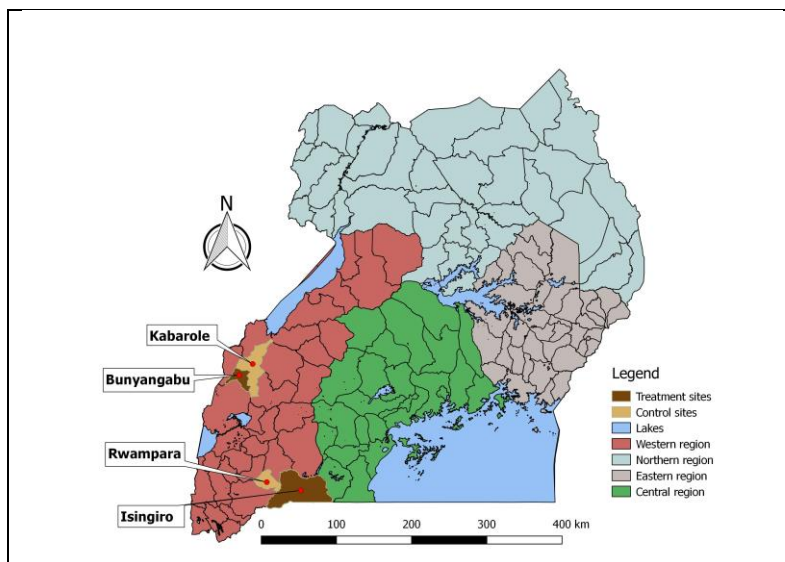


Figure 5.1: Map of Uganda showing the study area.

Farm households were randomly selected for interview in the study sites at the onset of the research. Data used in this study comprised three waves of panel surveys collected from 311 rural smallholder households, 53.7% of which were in the treatment group. In the control sites, information was channelled through the radio talk show (audio channel), whereas those in the treatment group also received information through audio-visual and practical approaches in addition to the audio channel. The first wave of data was collected in 2017 before the onset of the agronomy extension-based campaign. This corresponds to the baseline/pre-shock period. The second wave which corresponds to the shock period was collected in 2021 during the pandemic in the second countrywide lockdown. The third wave was taken in 2022 after the intervention period as households were recovering from the effects of the pandemic and this corresponds to the endline/post-shock period in our analysis. The

surveys gathered information on household demographics, assets, agricultural crop and livestock production, adoption of agronomic practices, shocks, coping strategies, food consumption and expenditure, non-food expenditure, income, and credit sources, savings, household social networks and associations, government safety nets, and the participation in other assistance programs.

## **5.4 Methodology**

### *5.4.1 Resilience analysis*

We adopt the Resilience Index Measurement and Analysis (RIMA) approach (FAO, 2016), which is an updated version of the FAO-RIMA model (Alinovi et al., 2008). The RIMA methodology has been extensively used and field-tested in over 20 African countries (d’Errico et al., 2018; d’Errico & Di Giuseppe, 2018; Lascano, 2020). It employs structural equation models (SEM) to estimate a multidimensional combined measure of resilience capacity from nearly 20 indicators and household characteristics. The methodology identifies resilience as a latent variable in relation to food security outcomes, as well as its determinants – the pillars.

The model is graphically represented in Figure 5.2. It consists of the estimation of a Resilience Capacity Index (RCI) that derives from the combination of various directly observable household characteristics and captures household resilience to food insecurity. The household resilience capacity denoted as  $R_0$  in Figure 5.2 has four components known as pillars namely Access to Basic Services (ABS), Assets (AST), Social Safety Nets (SSN), and Adaptive Capacity (AC). ABS is an indicator of a household's capacity to engage with an enabling institutional and public service environment. It depicts the household's ability to meet basic needs, and its access to and effective use of basic services such as schools, health facilities, markets, stores, paved roads, safe water, and waste disposal systems (Agüero et al., 2007). The assets pillar comprises both productive and non-productive assets. Productive assets are the key elements of a livelihood, enabling households to produce consumable or tradable goods, whereas non-productive assets reflect the household's wealth and living standards. The SSN pillar encompasses the network upon which a household can rely when faced with a shock including friends, relatives, the community, government, charities, and non-governmental organisations. Adaptive

capacity is the ability of a household to adjust to a new situation and develop new livelihood strategies amidst disturbances (Alinovi et al., 2008).

The dynamic framework in Figure 5.2 depicts two points in time, the pre- and post-shock periods denoted by  $t_0$  and  $t_1$  respectively, and the corresponding welfare indicator which is usually a measure of food security denoted as  $Y_0$  and  $Y_1$ , respectively. We use two food security metrics namely the household dietary diversity score and food expenditure per capita. When a shock occurs, it causes a change in both household resilience (depicted by  $\Delta Res$ ) and food security (depicted by  $\Delta Y$ ), and a series of coping strategies are activated, mainly consumption smoothing, assets smoothing, and adoption of new livelihood strategies to enable the household to bounce back to its original level of resilience capacity,  $R_0$ . The results of the interplay between the effects of shocks and coping strategies translate into a new level of food security,  $Y_1$ , which may be one of the three possible outcomes: reduced (if  $Y_1 < Y_0$ ), stable (if  $Y_1 = Y_0$ ), or increased (if  $Y_1 > Y_0$ ) food security. This outcome,  $Y_1$  affects resilience capacity and, consequently, the future capacity to respond to shocks.

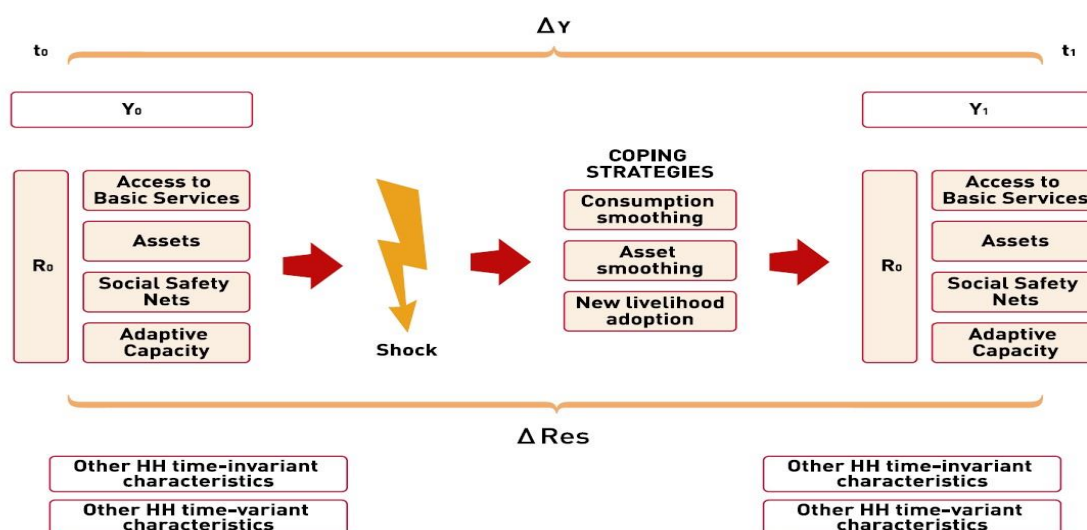


Figure 5.2: The RIMA approach. Adapted from FAO (2016).

Note:  $t_0$  is the pre-shock period and  $t_1$  is the post-shock period.  $Y_0$  and  $Y_1$  are the levels of food security during the pre- and post-shock periods respectively.  $R_0$  is the household resilience capacity whereas  $\Delta Res$  and  $\Delta Y$  are the changes in the resilience and food security respectively that occur due to the shock.

The RIMA model was employed to identify key aspects that significantly influenced household resilience capacity in the face of shocks. This model estimates the Resilience Capacity Index (RCI) at

the household level using a two-stage procedure (FAO, 2016), as illustrated in Figure 5.3. In the first step, Factor Analysis is used to identify the attributes—called *pillars* within the RIMA framework—that contribute to household resilience, starting from observed variables which are represented by  $v_1, v_2, \dots, v_n$  in Figure 5.3. The pillars are Access to Basic Services (ABS), Assets (AST), Social Safety Nets (SSN) and Adaptive Capacity (AC). Each of the pillars is a latent variable that is constructed from the observed variables. For example, the observed variables that constitute the social safety nets pillar include having access to remittances and credit (i.e., the household is not credit-constrained), and membership in associations such as farmers’ groups, savings groups and/or self-help groups. A description of all the observed variables that are used in the estimation of each pillar is provided in Table A5 in the appendix. Through factor analysis, these variables were used to estimate the pillars and the factors considered for each pillar are only those able to explain at least 95% of the variance (d’Errico et al., 2023; FAO, 2016). Our campaign intervention is expected to enhance the resilience capacity of the treated households through three of the four resilience pillars: access to basic services through improved market access, social safety nets through farmer groups and credit access, and adaptive capacity through increased access to information and savings.

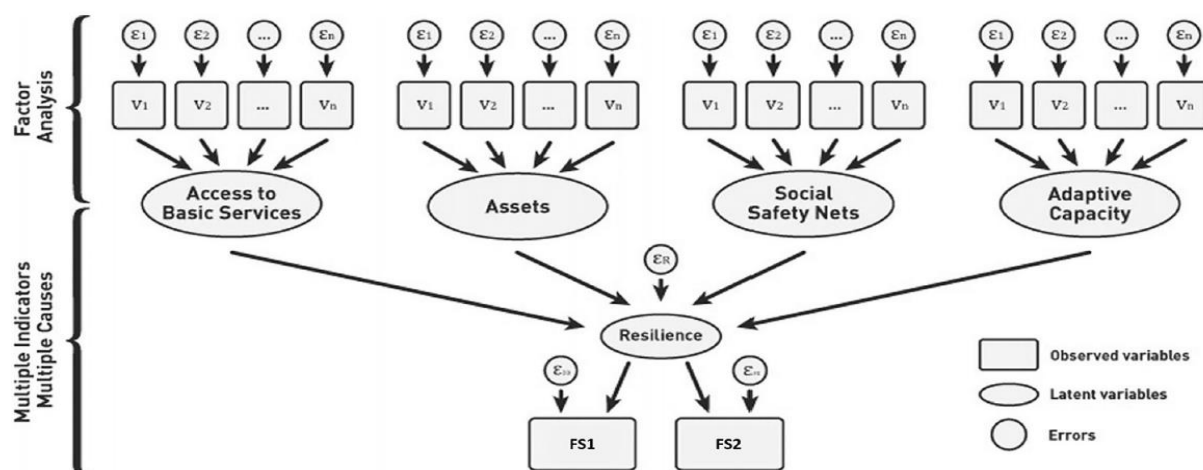


Figure 5.3: Path diagram of the household’s resilience model, adapted from FAO (2016).

In the second step, a Multiple Indicators Multiple Causes (MIMIC) model is used (Bollen et al., 2010). Specifically, a system of equations is constructed through structural equation modelling, specifying the relationships between an unobservable latent variable (resilience), a set of outcome indicators (food

security indicators denoted as FS1 and FS2 in Figure 5.3) and a set of attributes (pillars). Factor Analysis—employed in the first step—assumes that the residual errors (i.e., unique factors) are uncorrelated with each other and are uncorrelated with the latent variable. In the case of food security analyses, the latter assumption is not maintained, as the probability of intra-dimension correlation is high (FAO, 2016). Structural equation modelling allows correlation among residual errors (d’Errico et al., 2018).

The MIMIC model is made up of two components, namely the measurement equation (1)—reflecting that the observed indicators of food security are imperfect indicators of resilience capacity— and the structural equation (2), which correlates the estimated attributes to resilience:

$$\begin{pmatrix} \text{Household Dietary Diversity} \\ \text{Food expenditure per capita} \end{pmatrix} = [\Lambda_1, \Lambda_2] \times [RCI] + [\varepsilon_1, \varepsilon_2] \quad (1)$$

where  $\Lambda_1$  is the coefficient of the household dietary diversity score and  $\Lambda_2$  is the coefficient of food expenditure per capita.  $\varepsilon_1$  and  $\varepsilon_2$  are error terms. The resilience capacity index is then specified as a function of the pillars as follows:

$$[RCI] = [\beta_1, \beta_2, \beta_3, \beta_4] \times \begin{bmatrix} ABS \\ AC \\ AST \\ SSN \end{bmatrix} + \varepsilon_3 \quad (2)$$

where RCI is the Resilience Capacity Index,  $\beta_1$  to  $\beta_4$  are coefficients of the pillars to be estimated, namely Access to Basic Services (ABS), Adaptive Capacity (AC), Assets (AST) and Social Safety Nets (SSN), and  $\varepsilon_3$  is the error term.

The latent variable model above should not be interpreted as a causal inference model. This is because of the potential endogeneity that arises when the latent construct, which is the resilience capacity index (RCI) is jointly determined with the outcome of interest such as dietary diversity/food expenditure per capita, or is correlated with the error term,  $\varepsilon_3$ . Whereas the MIMIC does not completely solve the endogeneity problem, it can nevertheless smooth it (d’Errico et al., 2018). Furthermore, RIMA uses the MIMIC approach as a mere descriptive tool of the relationship between resilience and its components, while causal inference is left to subsequent regression analysis.

The estimated RCI is not anchored to any scale of measurement. Therefore, a scale has been defined setting the coefficient of the household dietary diversity score ( $\Lambda_1$ ) equal to 1, meaning that one standard deviation increase in RCI implies an increase of one standard deviation in the household dietary diversity score (HDDS). This also defines the unit of measurement for the coefficient for food expenditure per capita ( $\Lambda_2$ ) and for the variance of the two food security indicators. To ease understanding and interpretation of the results, the RCI is standardized through a min-max scaling transformation, based on the following formula:

$$RCI_h^* = \frac{RCI_h - RCI_{min}}{RCI_{max} - RCI_{min}} \times 100 \quad (3)$$

where  $h$  represents the  $h^{\text{th}}$  household.

#### 5.4.2 Causal analysis

To determine the impact of the banana agronomy extension-based campaign, on the resilience and welfare of the households during the study period, we use a difference-in-differences (DID) model which is stated as follows:

$$Y_{it} = \beta_0 + \beta_1 Post_t + \beta_2 T_i + \beta_3 (Post_t * T_i) + \beta_4 X_i + \varepsilon_i \quad (4)$$

where;  $Y_{it}$  is a resilience (RCI) / food security measure (HDDS, Food expenditure per capita);  $Post_t$  is a binary time variable equal to 1 for periods after the intervention, 0 for the baseline;  $T_i$  is a binary variable equal to 1 if household  $i$  is in the treatment group, 0 for the control group;  $X_i$  is a vector of baseline covariates;  $\beta_0$  to  $\beta_4$  are coefficients to be estimated; and  $\varepsilon_i$  is a random error term clustered at subcounty level. The coefficient of interest,  $\beta_3$  is the DID estimator, representing the average treatment effect on the treated.

##### 5.4.2.1 Impact of shocks and the buffering effect of the campaign intervention

Resilience denotes households' capacity to recover, particularly from various shocks. Another way of evaluating the impact of the intervention on resilience is to assess whether it mitigated the adverse effects of these shocks on households' well-being. The shock period under consideration (denoted as  $t_l$  in equation 5) corresponds to the period when the government of Uganda instituted stringent COVID-19

control measures including the four-month-long lockdown in 2021 (Bitzer et al., 2024). The recovery/post-shock period,  $t_2$  corresponds to 2022 when all the restrictions were lifted. For this analysis, therefore, we employ the data collected in June-July 2021 during the lockdown and the endline/post-shock dataset collected a year later.

To evaluate the impact of shocks and whether the intervention served to reduce the negative impact of the shocks on household well-being, we use a standard growth regression where the change in the household's food security over time is the dependent variable (Hoddinott & Kinsey, 2001; Yamano et al., 2005). We include an interaction term between the measure of shock exposure and the treatment dummy (Knippenberg & Hoddinott, 2019; Smith & Frankenberger, 2022), as shown in the following equation:

$$Y_{i,t2} - Y_{i,t1} = \beta_0 + \beta_1 T_i + \beta_2 SE_{i,t1} + \beta_3 (T_i * SE_{i,t1}) + \beta_4 Y_{i,t1} + \beta_5 X_i + \beta_6 CS_{i,t1} + \beta_7 L_i + \varepsilon_i \quad (5)$$

where,  $Y_{i,t2}$  is the food security measure (HDDS, Food expenditure per capita) in 2022;  $Y_{i,t1}$  is the food security measure (HDDS, Food expenditure per capita) in 2021;  $T_i$  is a binary variable equal to 1 if household  $i$  is in the treatment group, 0 otherwise;  $SE_{i,t1}$  is the shock severity index (computed as shown in equation 6);  $X_i$  is a vector of baseline household characteristics;  $CS_{i,t1}$  represents dummy variables for coping strategies employed in the shock period i.e. asset smoothing, non-food consumption smoothing and new livelihood adoption;  $L_i$  is a dummy variable equal to 1 if household  $i$  is located in mid-western Uganda, 0 otherwise;  $\beta_0$  to  $\beta_7$  are coefficients to be estimated; and  $\varepsilon_i$  is a random error term clustered at subcounty level.

The shock severity index ( $SE_{i,t1}$ ) was created to measure the overall degree of shock exposure for each household. It was based on a total of 21 shocks belonging to five categories namely climate-related shocks (6), economic (6), health (4) and mobility shocks (5). A detailed list of these shocks is provided in Table 5. The index is calculated as a weighted average of the incidence of each shock (a dummy variable equal to 1 if the shock was experienced, 0 otherwise) and its severity.

The severity of the shock is measured as an additive index of dummy variables indicating whether the shock led to a decline in household (i) income, (ii) assets, (iii) food production, and/or (iv) food purchases. For example, if a household reported experiencing a shock such as pests and diseases, they would indicate whether it resulted in reductions in any of these four welfare parameters. The severity index is calculated as the sum of the effects on these welfare parameters. For instance, if pests and diseases caused reductions in household income and food production, the severity index would equal two. The index ranges from zero, representing the least severe scenario (no effect on any parameter), to four, representing the most severe scenario (implying declines in income, assets, food production, and food purchases). The index is computed as shown in the following equation:

$$SE_{i,t1} = \sum_{i=1}^{21} shock_i * Sev\_shock_i \quad (6)$$

where:  $shock_i$  is the shock exposure dummy equal to 1 if experienced, 0 otherwise;  $Sev\_shock_i$  is the shock severity based on its effect on household income, assets, food production, and food purchases.

## 5.5 Results and discussion

### 5.5.1 Resilience analysis

The RIMA approach yields two outputs: an estimate of the resilience capacity index (RCI) and an assessment of how the different attributes correlate with resilience. The results of the first step obtained through factor analysis are presented in the Appendix (Tables 5.1A–5.4A). Results of the second step—the Multiple Indicators Multiple Causes (MIMIC) model are presented in Table 5.1. As explained earlier, the MIMIC model comprises two components/equations: the measurement component shown in equation (1) and the structural component indicated in equation (2). The results for equation (1) are provided under the measurement component section (B) in the middle of Table 5.1. Since the estimated RCI is not anchored to any scale of measurement, the model sets the coefficient of the household dietary diversity score ( $\Lambda_1$ ) equal to 1 (as shown in the table), meaning that one standard deviation increase in RCI implies an increase of one standard deviation in the household dietary diversity score (HDDS). The coefficient of the food expenditure per capita ( $\Lambda_2$ ) is 2.664 implying that one standard deviation increase in RCI corresponds to an increase of 2.664 standard deviations in food expenditure per capita.

Table 5.1 Results of the estimated MIMIC model for estimating household resilience index

|   | Coefficient | Standard errors |
|---|-------------|-----------------|
| <b>A) <u>Structural Component</u></b>             |             |                 |
| Access to Basic Services (ABS)                    | 0.195       | (0.130)         |
| Adaptive Capacity (AC)                            | 0.062       | (0.070)         |
| Assets (AST)                                      | 0.673***    | (0.082)         |
| Social Safety Nets (SSN)                          | 0.608***    | (0.095)         |
| <b>B) <u>Measurement component</u></b>            |             |                 |
| Household Dietary Diversity Score ( $\Lambda_1$ ) | 1.000       | (0.000)         |
| Per capita food expenditure ( $\Lambda_2$ )       | 2.664***    | (0.547)         |
| <b>C) <u>Goodness of fit tests</u></b>            |             |                 |
| Chi2  | 11.737      |                 |
| P > Chi2  | 0.008       |                 |
| RMSEA   | 0.056       |                 |
| P RMSEA   | 0.328       |                 |
| CFI   | 0.968       |                 |
| TLI   | 0.905       |                 |
| SRMR  | 0.021       |                 |
| Number of observations                            | 933         |                 |

Standard errors in parentheses. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% level respectively. The Table presents results of equation (1) that corresponds to the measurement component (B) and equation (2) that comprises the structural component (A) as well as the MIMIC model goodness of fit tests (C).

The results corresponding to equation (2) are listed under the structural component section (A) at the top in Table 5.1. The values of the coefficients of the pillars namely Access to Basic Services (ABS), Adaptive Capacity (AC), Assets (AST), and Social Safety Nets (SSN) correspond to  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$ , and  $\beta_4$ , respectively. The coefficients for the assets and social safety nets pillars have the highest magnitude and are statistically significant. These results imply that the assets (AST) and social safety nets (SSN) pillars have the highest explanatory weight in determining resilience and are statistically significant at the 1% level. Asset ownership is vital for households' wellbeing in the study area and can be used as collateral for accessing credit and as a buffer amidst shocks particularly among the poor households (d'Errico et al., 2023). Social safety nets that represent access to social capital and transfers, whether cash or in-kind, are a major source of poverty alleviation in many developing countries. These results are in line with Lascano (2020) and d'Errico et al., (2023) who conducted similar studies in developing countries, Uganda inclusive, and found that asset ownership and social safety nets contribute significantly to

household resilience. The access to basic services (ABS) and adaptive capacity (AC) pillars in our study play a marginal role and are not statistically significant.

The MIMIC model goodness of fit tests are presented in section C at the bottom of Table 5.1. The Chi square value should not be significant for a good fit. However, this statistic is affected by sample size, so it may sometimes be significant for a good fit model (Pituch & Stevens, 2016). The Root Mean Square Error of Approximation (RMSEA) evaluates model fit based on the deviance between the estimated and real covariances hence it should be close to zero and should not be significant for a good fit as shown by the p-value, P RMSEA (Brück et al., 2019; FAO, 2016). The closer the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI) are to unity, the better the model fit (Pituch & Stevens, 2016). On the contrary, the Standardized Root Mean Squared Residual (SRMR) should be close to zero for a close-fitting model (FAO, 2016; Pituch & Stevens, 2016). Based on these tests, the MIMIC results present a good fit for the data.

Figure 5.4 illustrates the variable weight in determining the pillars by their components<sup>11</sup>, as a result of the factor analysis. Each radar chart represents a pillar, and the variables constituting that pillar. The further the spike is away from the centre, the greater the relevance of that variable. Having a spike close to the centre implies that the influence of that variable on the pillar is close to zero. In the case of Access to basic services (ABS) pillar, the distances to tarmac road and agricultural markets were relevant variables in determining the household Resilience Capacity Index (RCI) through this pillar. On the other hand, the ratio of income earners to total household members contributed the most towards the Adaptive Capacity (AC) pillar. The agricultural asset index was the most important variable for the assets (AST) pillar. Considering the Social Safety Nets (SSN) pillar, households that had access to credit belonged to associations such as farmers' groups, village savings and self-help groups were more resilient.

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<sup>11</sup> The description of the variables/indexes constituting the pillars is provided in Table A5 in the Appendix.

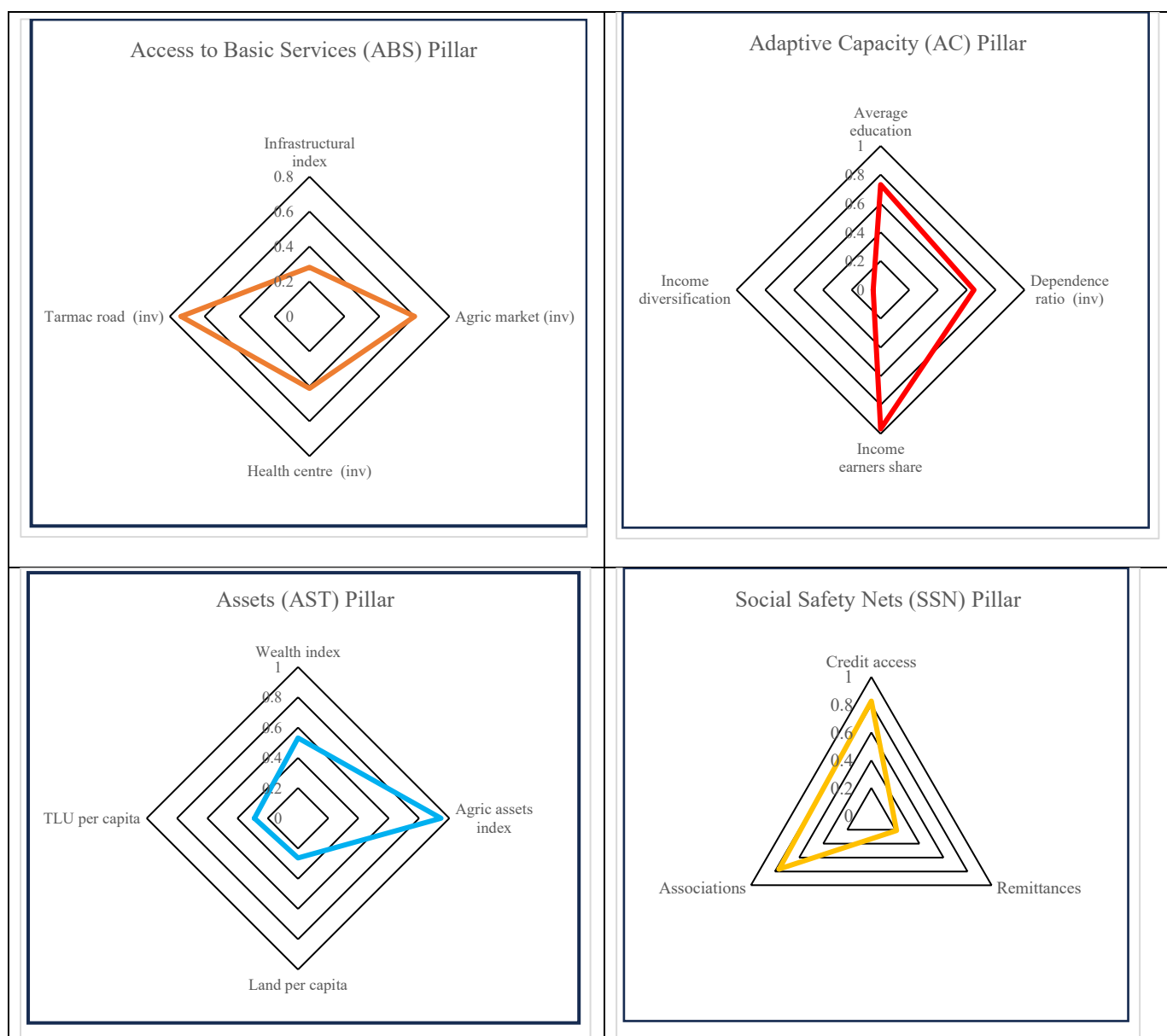


Figure 5.4: Resilience structure by pillar disaggregation.

Note: Each radar chart represents a pillar and the variables constituting it. The further the spike is away from the centre, the greater the relevance of the variable in determining the pillar.

## 5.5.2 Impact of the agronomy extension-based campaign on household welfare

### 5.5.2.1 Randomization

Table 5.2 presents covariate balancing tests that assess the effectiveness of the randomization procedure. Our results provide evidence that the randomization procedure was balanced across the treatment and control groups, since the baseline variables, except for marital status, are not significantly different between the two groups. This implies that randomization bias is not a major concern in our study. Since there is a significantly higher number of married household heads in the treatment group than in the

control group, we include baseline covariates in the analyses to improve the precision of the estimates (Athey & Imbens, 2017).

Table 5.2 Balance of randomization

|  | Pooled Sample |        | Treatment group |        | Control group |        | Mean difference |
|--|---------------|--------|-----------------|--------|---------------|--------|-----------------|
|  | Mean          | SD     | Mean            | SD     | Mean          | SD     | Treated-Control |
| <u>Outcome variables</u>                 |               |        |                 |        |               |        |                 |
| Resilience Capacity Index (RCI)          | 65.262        | 10.017 | 65.294          | 10.022 | 65.225        | 10.047 | 0.069           |
| Household Dietary Diversity Score (HDDS) | 7.441         | 2.165  | 7.527           | 2.136  | 7.340         | 2.200  | 0.187           |
| Food expenditure per capita (USD)        | 20.807        | 16.664 | 20.727          | 15.372 | 20.901        | 18.102 | -0.174          |
| <u>Control variables</u>                 |               |        |                 |        |               |        |                 |
| Household size (adult equivalent)        | 4.898         | 1.918  | 4.953           | 1.869  | 4.835         | 1.978  | 0.118           |
| Female household head (1=Yes)            | 0.215         | 0.412  | 0.186           | 0.390  | 0.250         | 0.435  | -0.064          |
| Age of household head (years)            | 51.344        | 15.118 | 51.389          | 14.034 | 51.292        | 16.335 | 0.098           |
| Household head is married (1=Yes)        | 0.743         | 0.438  | 0.796           | 0.404  | 0.681         | 0.468  | 0.116**         |
| Household head is a farmer (1=Yes)       | 0.839         | 0.368  | 0.868           | 0.339  | 0.806         | 0.397  | 0.063           |
| Number of observations                   | 311           |        | 167             |        | 144           |        |                 |

SD denotes standard deviation. \*\*\*, \*\*, and \* denote that the mean difference is significant at the 1%, 5%, and 10% level respectively. The treatment group was exposed to all the information dissemination channels including audio, audio-visual and hands-on approaches whereas the control group was only exposed to the audio channel.

#### 5.5.2.2 Resilience and Food Security Trends

Resilience dynamics are accounted for when panel data is utilized to examine how resilience evolves over time, usually by analysing the level of resilience and food security before and after a major shock (d'Errico & Di Giuseppe, 2018). Table 5.3 presents the trend in household resilience capacity and food security indicators before, during, and after the pandemic, illustrating the changes in the indicators over time. The pre-shock period in this study corresponds to 2017 when the baseline data was collected, while 2021 is the pandemic/shock period and 2022 is the post-shock/recovery period. The results reveal that the household resilience capacity index (RCI) significantly increased throughout the study period. However, there was a decline in food security amidst the pandemic, though only the decline in food expenditure per capita is significant at the 10% level. During the post-shock period, there was a significant improvement in food security which is indicative of a recovery phase.

Table 5.3 Changes in resilience and food security over time

|                                   | <b>2017</b>        | <b>2021</b>        | <b>2022</b>        | <b>2021-2017<sup>a</sup></b> | <b>2022-2021<sup>b</sup></b> |
|-----------------------------------|--------------------|--------------------|--------------------|------------------------------|------------------------------|
|                                   | Mean               | Mean               | Mean               | Mean                         | Mean                         |
|                                   |                    |                    |                    | difference                   | difference                   |
| Resilience Capacity Index         | 65.262<br>(10.017) | 67.693<br>(10.464) | 72.865<br>(10.597) | 2.431***                     | 5.172***                     |
| Household Dietary Diversity Score | 7.441<br>(2.165)   | 7.248<br>(2.035)   | 8.064<br>(1.807)   | -0.193                       | 0.816***                     |
| Food expenditure per capita       | 20.807<br>(16.664) | 18.898<br>(10.957) | 20.351<br>(10.806) | -1.910*                      | 1.453*                       |

The figures in parentheses are standard deviations. <sup>a</sup> denotes the mean difference between the shock and pre-shock periods whereas <sup>b</sup> denotes the mean difference between the post-shock and shock periods. \*\*\*, \*\*, and \* denote that the mean difference is significant at the 1%, 5%, and 10% level respectively.

### 5.5.2.3 Impact analysis

The impact analysis results of the difference-in-differences (DID) model specified in equation (4) are presented in Table 5.4. The Average Treatment Effect on the Treated (ATT) is positive for all the welfare indicators. Thus, utilising multiple information dissemination channels in the extension-based agronomy campaign improved the welfare of farming households, although the impact was only significant for dietary diversity. Relatedly, various studies have found positive and significant impacts of agricultural extension interventions on food security (Larsen & Lilleør, 2014; Pan et al., 2018) and specifically on household dietary diversity (Matchaya & Chilonda, 2012).

Table 5.4 Impact of the intervention on resilience and the welfare of households

| Welfare indicator                        | ATT                |
|--|--------------------|
| Resilience Capacity Index (RCI)          | 1.799<br>(2.225)   |
| Household Dietary Diversity Score (HDDS) | 0.903**<br>(0.208) |
| Food expenditure per capita              | 1.846<br>(1.733)   |

The figures in parentheses are robust standard errors. \*\*\*, \*\*, and \* denote that the mean difference is significant at the 1%, 5%, and 10% level respectively. ATT denotes average treatment effect on the treated which signifies the impact of the extension campaign on household welfare. The control variables used in the estimation are as listed in Table 5.2.

#### 5.5.2.4 Shocks

The most frequently reported shocks were economic and mobility-related as presented in Table 5.5. Majority of the households were adversely affected by the disruptions in transport that also affected both input and output markets. Over half (59%) of the households reported high costs of foodstuffs and other household essentials, including soap and cooking fuels among the greatest economic challenges that they faced during the pandemic. Furthermore, reduced off-farm earnings, low prices for farm produce and limited market, increased the vulnerability of the rural households to poverty and food insecurity. Significantly more households in the treatment group reported produce market-related shocks than those in the control group. On the other hand, 20% of the households experienced a reduction in off-farm earnings and over 15% of the households reported increased outbreaks of crop pest and diseases and these stressors were more rampant among the households in the control group. The reduction in off-farm income could be attributed to the effects of the pandemic during which many businesses were closed, and several people lost their jobs as noted by Kansiime et al. (2021) and Bitzer et al. (2024). It is also likely that households in the treatment group that had access to information through multiple channels adopted the crop pest and disease control practices that were promoted, hence they were less affected by these challenges than those in the control group.

Table 5.5 Climate-change and COVID-19-induced shocks.

|                               | Pooled Sample |       | Treatment group |       | Control group |       | Mean difference |
|-------------------------------|---------------|-------|-----------------|-------|---------------|-------|-----------------|
|                               | Mean          | SD    | Mean            | SD    | Mean          | SD    | Treated-Control |
| <u>Climate-related shocks</u> |               |       |                 |       |               |       |                 |
| Drought                       | 0.090         | 0.287 | 0.114           | 0.318 | 0.062         | 0.243 | 0.051           |
| Irregular rains               | 0.132         | 0.339 | 0.138           | 0.346 | 0.125         | 0.332 | 0.013           |
| Floods                        | 0.058         | 0.234 | 0.078           | 0.269 | 0.035         | 0.184 | 0.043           |
| Landslides                    | 0.006         | 0.080 | 0.000           | 0.000 | 0.014         | 0.117 | -0.014          |
| Crop pests and diseases       | 0.154         | 0.362 | 0.120           | 0.326 | 0.194         | 0.397 | -0.075*         |
| Livestock diseases            | 0.077         | 0.267 | 0.090           | 0.287 | 0.062         | 0.243 | 0.027           |
| <u>Economic shocks</u>        |               |       |                 |       |               |       |                 |
| Employment loss               | 0.045         | 0.208 | 0.042           | 0.201 | 0.049         | 0.216 | -0.007          |

|                                     |       |       |       |       |       |       |          |
|-------------------------------------|-------|-------|-------|-------|-------|-------|----------|
| Reduction in earnings (off-farm)    | 0.203 | 0.403 | 0.156 | 0.364 | 0.257 | 0.438 | -0.101** |
| High cost of foodstuff & essentials | 0.585 | 0.493 | 0.563 | 0.498 | 0.611 | 0.489 | -0.048   |
| Limited market for produce          | 0.350 | 0.478 | 0.449 | 0.499 | 0.236 | 0.426 | 0.213*** |
| High cost of agric. inputs          | 0.010 | 0.098 | 0.012 | 0.109 | 0.007 | 0.083 | 0.005    |
| Drop in prices of agric. produce    | 0.498 | 0.501 | 0.623 | 0.486 | 0.354 | 0.480 | 0.269*** |

Health (physical & mental) shocks

|                              |       |       |       |       |       |       |        |
|------------------------------|-------|-------|-------|-------|-------|-------|--------|
| Illness of income earner     | 0.074 | 0.262 | 0.072 | 0.259 | 0.076 | 0.267 | -0.005 |
| Illness of household members | 0.071 | 0.257 | 0.072 | 0.259 | 0.069 | 0.255 | 0.002  |
| Death of household members   | 0.023 | 0.149 | 0.030 | 0.171 | 0.014 | 0.117 | 0.016  |
| Intrahousehold conflicts     | 0.051 | 0.221 | 0.066 | 0.249 | 0.035 | 0.184 | 0.031  |

Mobility shocks

|  |       |       |       |       |       |       |          |
|--|-------|-------|-------|-------|-------|-------|----------|
| Lack of transport                                | 0.637 | 0.482 | 0.641 | 0.481 | 0.632 | 0.484 | 0.009    |
| Post harvest losses due to transport disruptions | 0.141 | 0.349 | 0.204 | 0.404 | 0.069 | 0.255 | 0.134*** |
| Difficulty in accessing inputs                   | 0.023 | 0.149 | 0.036 | 0.187 | 0.007 | 0.083 | 0.029*   |
| Difficulty in accessing output markets           | 0.080 | 0.272 | 0.090 | 0.287 | 0.069 | 0.255 | 0.020    |
| Disruption in farm activities                    | 0.010 | 0.098 | 0.006 | 0.077 | 0.014 | 0.117 | -0.008   |

Overall shock index

|                        |       |       |       |       |       |       |          |
|------------------------|-------|-------|-------|-------|-------|-------|----------|
| Shock severity index   | 6.148 | 4.513 | 6.904 | 4.988 | 5.271 | 3.718 | 1.633*** |
| Number of observations | 311   |       | 167   |       | 144   |       |          |

SD denotes standard deviation. Each shock is listed under its respective category and the overall shock index is indicated at the bottom of the table. The treatment group was exposed to all the information dissemination channels including audio, audio-visual and hands-on approaches whereas the control group was only exposed to the audio channel. \*\*\*, \*\*, and \* denote that the mean difference between the treatment and the control groups is significant at the 1%, 5%, and 10% level respectively.

#### 5.5.2.5 Coping Strategies

Coping strategies are remedies employed by smallholders, mostly over short periods, to withstand shocks (Bahta, 2020). Furthermore, coping strategies are considered as the actions and activities that households engage in to reduce economic, environmental, and social vulnerability (d'Errico et al., 2023). When hit by a multitude of shocks, most households in our study resorted to changing their consumption

behaviour as a coping mechanism as shown in Table 5.6. About 66% involuntarily changed their dietary patterns, and these changes included eating smaller food portions or less diverse diets, consuming affordable foods that in some cases were less nutritious than those they desired and skipping meals in extreme cases. Furthermore, 62% of the households reduced expenditure on foodstuffs and other essentials. This is in line with Kansiime et al. (2021), who reported that 55% of respondents in Uganda changed their diets involuntarily amidst the pandemic. Also, in a study conducted in 35 countries including Uganda, d'Errico et al. (2023) found that 60% of the households resorted to consuming less diverse diets and reducing the quantity of food consumed to cope with shocks and stressors during the pandemic.

To curb the spread of COVID-19, majority refrained from moving from one place to another, adhering to the travel restrictions that were instituted countrywide. About 36% of the households relied on savings, 33% changed cropping practices including crop choices and/or technologies, 29% relied on support from relatives and friends, whereas 10% of the households resorted to distress sales of livestock as a coping mechanism. For all the coping strategies employed, the trend was similar among the households in the treatment and control groups, except for changes in health expenditure. A significantly higher proportion (about 5%) of households in the treatment group involuntarily cut back on their medical expenses, compared to less than 1% of those in the control group. This is detrimental to the wellbeing of the households and may result in the loss of lives in worst case scenarios.

Some households in our study employed asset smoothing as a coping strategy amidst shocks. Selling productive and non-productive assets is a common coping mechanism in the literature, especially among poor households (d'Errico et al., 2023; Lascano, 2020). However, this strategy may be perilous, particularly when households end up with an extremely low level of assets, thereby falling into a poverty trap, unable to make a living without external assistance (Banerjee & Duflo, 2011). Although access to productive and non-productive assets greatly contributes to households' ability to recover from shocks, restocking interventions might prevent falls into poverty traps.

Table 5.6 Coping Strategies

|                                       | Pooled Sample |       | Treatment group |       | Control group |       | Mean difference |
|---------------------------------------|---------------|-------|-----------------|-------|---------------|-------|-----------------|
|                                       | Mean          | SD    | Mean            | SD    | Mean          | SD    | Treated-Control |
| <u>Food-consumption smoothing</u>     |               |       |                 |       |               |       |                 |
| Changed dietary patterns              | 0.662         | 0.474 | 0.677           | 0.469 | 0.646         | 0.480 | 0.031           |
| Reduced expenditure on foodstuffs     | 0.624         | 0.485 | 0.629           | 0.485 | 0.618         | 0.488 | 0.011           |
| <u>Asset smoothing</u>                |               |       |                 |       |               |       |                 |
| Sold durable household assets         | 0.045         | 0.208 | 0.036           | 0.187 | 0.056         | 0.230 | -0.020          |
| Sold land/building                    | 0.023         | 0.149 | 0.024           | 0.153 | 0.021         | 0.143 | 0.003           |
| Rented out land/building              | 0.000         | 0.000 | 0.000           | 0.000 | 0.000         | 0.000 | 0.000           |
| Distress sales of animal stock        | 0.100         | 0.300 | 0.102           | 0.303 | 0.097         | 0.297 | 0.005           |
| <u>Non-food consumption smoothing</u> |               |       |                 |       |               |       |                 |
| Reduced expenditure on health         | 0.029         | 0.168 | 0.048           | 0.214 | 0.007         | 0.083 | 0.041**         |
| Reduced education expenditure         | 0.061         | 0.240 | 0.078           | 0.269 | 0.042         | 0.201 | 0.036           |
| Relied on savings                     | 0.363         | 0.482 | 0.353           | 0.479 | 0.375         | 0.486 | -0.022          |
| Obtained credit                       | 0.068         | 0.251 | 0.084           | 0.278 | 0.049         | 0.216 | 0.035           |
| <u>Adapting new livelihood</u>        |               |       |                 |       |               |       |                 |
| Relied on help from relatives         | 0.293         | 0.456 | 0.263           | 0.442 | 0.326         | 0.471 | -0.063          |
| Relied on help from local gov't       | 0.006         | 0.080 | 0.012           | 0.109 | 0.000         | 0.000 | 0.012           |
| Changed cropping practices            | 0.331         | 0.471 | 0.371           | 0.485 | 0.285         | 0.453 | 0.087           |
| Took on non-farm employment           | 0.061         | 0.240 | 0.078           | 0.269 | 0.042         | 0.201 | 0.036           |
| Took on farm wage employment          | 0.051         | 0.221 | 0.048           | 0.214 | 0.056         | 0.230 | -0.008          |
| Household member(s) migrated          | 0.010         | 0.098 | 0.006           | 0.077 | 0.014         | 0.117 | -0.008          |
| Sent children to live elsewhere       | 0.032         | 0.177 | 0.042           | 0.201 | 0.021         | 0.143 | 0.021           |
| Reduced hired labour on-farm          | 0.045         | 0.208 | 0.060           | 0.238 | 0.028         | 0.165 | 0.032           |
| Started a business                    | 0.032         | 0.177 | 0.036           | 0.187 | 0.028         | 0.165 | 0.008           |
| Started rearing animals               | 0.013         | 0.113 | 0.012           | 0.109 | 0.014         | 0.117 | -0.002          |
| Reduced movement                      | 0.633         | 0.483 | 0.653           | 0.478 | 0.611         | 0.489 | 0.042           |
| Number of observations                | 311           |       | 167             |       | 144           |       |                 |

SD denotes standard deviation. Each coping strategy is listed under its respective category. The treatment group was exposed to all the information dissemination channels including audio, audio-visual and hands-on approaches whereas the control group was only exposed to the audio channel. \*\*\*, \*\*, and \* denote that the mean difference between the treatment and the control groups is significant at the 1%, 5%, and 10% level respectively.

#### 5.5.2.6 *Buffering effect of the extension-based campaign*

Table 5.7 presents the results of the impact of the shocks and the buffering effect of the extension-based campaign, as specified in equation (5). Generally, the shocks and stressors that occurred during the pandemic had a more significant negative effect on food expenditure than on the diversity of diets. This is probably because of the income effect of the pandemic, whereby there was a decline in earnings and limited market for produce, so households consumed more from their own production (Béné et al., 2021). Health-related shocks had a significant negative impact on food expenditure per capita. Due to reduced income, farming households reduced health expenditure as a coping mechanism which was detrimental to their welfare. An earlier study by Nikoloski et al. (2018) on Uganda found that health-related shocks are detrimental and tend to be persistent, whereby households affected by human, livestock, or crop diseases in one year are more likely to experience a health shock in the following year. Furthermore, other studies conducted elsewhere show that in the presence of health shocks, households usually cope by taking credit (Dhanaraj, 2016; Pradhan & Mukherjee, 2018). However, if the health shock affects the head of household or the extremely poor households, the latter often respond by reducing food consumption or sending children to work. Similarly, Knight et al., (2015) found that health and economic shocks were commonly overcome by a reduction in consumption and general spending.

Participation in the extension-based campaign had a buffering effect against almost all shocks as shown by the positive results for the shock and treatment interaction. However, the intervention only significantly facilitated recovery from all shocks that affected per capita food expenditure, especially the mobility-related ones. This finding is consistent with Smith & Frankenberger (2018), who found that exposure to information and ownership of assets helped farmers in Bangladesh to mitigate the negative impact of shocks, mainly floods, on their household food security.

Table 5.7 Impact of shocks and the buffering effect of the intervention

|                                    | Overall<br>Shocks                 | Climate           | Economic          | Health               | Mobility           |
|------------------------------------|-----------------------------------|-------------------|-------------------|----------------------|--------------------|
|                                    | Household Dietary Diversity Score |                   |                   |                      |                    |
| Shock severity effect <sup>a</sup> | -0.007<br>(0.038)                 | 0.009<br>(0.093)  | -0.056<br>(0.072) | -0.148<br>(0.102)    | 0.185*<br>(0.105)  |
| Shock x Treatment <sup>b</sup>     | 0.030<br>(0.043)                  | 0.147<br>(0.114)  | 0.056<br>(0.086)  | 0.066<br>(0.133)     | -0.141<br>(0.114)  |
|                                    | Food Expenditure per Capita       |                   |                   |                      |                    |
| Shock severity effect <sup>a</sup> | -0.499*<br>(0.260)                | -0.610<br>(0.651) | -0.161<br>(0.498) | -1.995***<br>(0.694) | -0.845<br>(0.720)  |
| Shock x Treatment <sup>b</sup>     | 0.628**<br>(0.293)                | 0.938<br>(0.793)  | 0.241<br>(0.591)  | 0.727<br>(0.907)     | 1.701**<br>(0.785) |

Figures in parentheses are standard errors. <sup>a</sup> denotes the impact of the shocks on household food security, whereas <sup>b</sup> denotes the buffering effect of the campaign intervention against shocks. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% level respectively.

## 5.6 Conclusions

The concept of resilience has gained increasing significance over the last two decades because of climate variability and shocks from human and natural hazards. In this article, we employed panel data generated in three waves of farm household surveys in Uganda to analyse the resilience of the households in the face of climate change and COVID-19-related shocks. We also investigated the impact of an agronomy extension-based campaign we conducted, on the welfare of the households and its buffering effect against shocks that threatened their food security. Our extension-based approach involved dissemination of agricultural information to farmers through different channels in a randomised controlled trial setting. The treatment group received information through multiple channels including the audio channel (radio-talk shows), audio-visual (lecture-trainings and video shows) as well as hands-on practical approaches (farmer field days and demonstration trials). On the other hand, the control group only received information through audio means. The empirical results revealed that assets and social safety nets significantly contributed to the resilience capacity of smallholder households. Thus, increasing access to productive and non-productive assets to enable households to restore or maintain their stock of assets

would place them in a better position to respond to future shocks. Similarly, social safety nets (SSN), particularly access to credit and membership in associations such as farmer groups, self-help groups, and village savings and loan associations, cushioned households from shocks. Access to basic services and adaptive capacity are the least contributors to household resilience.

The results also showed that shocks negatively impacted household welfare. However, health-related shocks had a more devastating and significant impact, particularly on food expenditure. This was exacerbated by limited access to health centres, mobility restrictions, and detrimental coping strategies. However, exposure to the agronomy extension-based intervention had a positive and statistically significant impact on household welfare. Specifically, households that were exposed to the intervention improved their dietary quality. Furthermore, access to information /extension services helped buffer households from severe shocks affecting their standards of living including those that arose due to mobility restrictions.

#### *5.6.1 Policy implications*

Our findings have multifaceted policy implications. First, there is need to decentralize services, especially health facilities and other infrastructure such as tarmac roads and agricultural markets. This will increase access to these basic services and consequently contribute to household resilience. Second, farmers should be enlightened and exposed to other income-generating activities, including value addition to enable them to diversify and shield them from unprecedented eventualities. More so, investment in programs that decentralise extension services and improve the welfare and long-term resilience of rural farming households need to be prioritised. In addition, during crises, the government should offer support/relief in form of food or cash not only to the urban/peri-urban population as was the case during the pandemic, but also to rural households. This is because such calamities negatively affect the food security levels of smallholder farmers too, as ascertained in our study, despite the fact that they are food producers. This, coupled with the provision of basic services is bound to improve their resilience and prevent them from resorting to detrimental coping mechanisms amidst devastating shocks.

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## Appendix

### Factor Analysis

#### Access to Basic Services (ABS)

Table 5.1A Factor analysis results for the Access to Basic Services (ABS) pillar

|                         | Factor 1 | Factor 2 | Factor 3 | Uniqueness |
|-------------------------|----------|----------|----------|------------|
| Infrastructural index   | 0.141    | 0.131    | 0.100    | 0.953      |
| Agric market (inverse)  | 0.286    | -0.177   | 0.044    | 0.885      |
| Health centre (inverse) | 0.171    | 0.230    | -0.028   | 0.917      |
| Tarmac road (inverse)   | 0.372    | -0.019   | -0.059   | 0.858      |

The number of factors used for estimating ABS is 2. They jointly explain 96% of the variable variance.

#### Adaptive Capacity (AC)

Table 5.2A Factor analysis results for the Adaptive Capacity (AC) pillar

|                            | Factor 1 | Factor 2 | Factor 3 | Uniqueness |
|----------------------------|----------|----------|----------|------------|
| Income diversification     | 0.049    | 0.225    | 0.137    | 0.928      |
| Dependence ratio (inverse) | 0.632    | -0.169   | 0.134    | 0.554      |
| Average education          | 0.669    | 0.235    | -0.055   | 0.494      |
| Income earners share       | 0.858    | -0.071   | -0.064   | 0.255      |

The number of factors used for estimating AC is 2. They jointly explain 98% of the variable variance.

#### Assets (AST)

Table 5.3A Factor analysis results for the Assets (AST) pillar

|                    | Factor 1 | Factor 2 | Factor 3 | Uniqueness |
|--------------------|----------|----------|----------|------------|
| Agric assets index | 0.652    | -0.179   | -0.060   | 0.539      |
| Wealth index       | 0.487    | 0.048    | 0.198    | 0.722      |
| TLU per capita     | 0.331    | 0.461    | -0.149   | 0.655      |
| Land per capita    | -0.097   | 0.614    | 0.079    | 0.607      |

The number of factors used for estimating AST is 2. They jointly explain 95% of the variable variance.

#### Social Safety Nets (SSN)

Table 5.4A Factor analysis results for the Social Safety Nets (SSN) pillar

|                            | Factor 1 | Factor 2 | Uniqueness |
|----------------------------|----------|----------|------------|
| Remittances                | 0.144    | 0.200    | 0.940      |
| Membership in associations | 0.523    | -0.117   | 0.712      |
| Credit access              | 0.565    | 0.058    | 0.678      |

The number of factors used for estimating SSN is 2. They jointly explain 100% of the variable variance.

Note: Factor analysis necessitates that the variables analysed are in the same direction therefore for some variables, the inverse was used (FAO, 2016).

Table 5.5A Descriptives

| Variable                                 | Description   | Pooled Sample |        |
|--|---|---------------|--------|
|  |   | Mean          | SD     |
| <b><u>Covariates</u><sup>a</sup></b>     |   |               |        |
| Female household head                    | Dummy=1 if yes  | 0.215         | 0.412  |
| Age household head                       | Years   | 51.344        | 15.118 |
| Household head is married                | Dummy=1 if yes  | 0.743         | 0.438  |
| Household size                           | Adult equivalent  | 4.898         | 1.918  |
| Household head is a farmer               | Dummy=1 if yes  | 0.839         | 0.368  |
| <b><u>RCI estimation</u><sup>b</sup></b> |   |               |        |
| <b>Access to Basic Services (ABS)</b>    |   |               |        |
| Infrastructure index                     | PCA: Improved floor, improved wall, improved toilet, access to running water and electricity.                         | -0.156        | 1.556  |
| Agric market distance                    | Km  | 4.287         | 3.837  |
| Health centre distance                   | Km  | 4.084         | 5.458  |
| Tarmac road distance                     | Km  | 4.895         | 4.443  |
| <b>Adaptive Capacity (AC)</b>            |   |               |        |
| Average education of household members   | Years   | 5.279         | 2.617  |
| Dependence ratio                         | Share of dependents   | 1.144         | 0.914  |
| Income diversification                   | PCA: income sources   | 0.053         | 1.090  |
| Income earners share                     | Share of working members  | 0.546         | 0.226  |
| <b>Assets (AST)</b>                      |   |               |        |
| Wealth index                             | FA: Ownership of Building, Phone, Radio, Television, Motorcycle, Vehicle, Bicycle, Solar,                             | -0.011        | 0.279  |
| Agric asset index                        | FA: Ownership of Spades, Shovels, Spray pumps, Wheelbarrows, Water tanks, Pruning knives, Axes, Forked hoes, Slashers | -0.051        | 0.243  |
| Land per capita                          | Acres   | 0.220         | 0.416  |
| TLU per capita                           | Tropical livestock units per capita   | 0.041         | 0.098  |
| <b>Social Safety Nets (SSN)</b>          |   |               |        |

|   |   |        |        |
|---|---|--------|--------|
| Credit access                               | Dummy=1 if yes                                      | 0.328  | 0.470  |
| Remittances                                 | Uganda Shillings                                    | 0.008  | 0.052  |
| Number of associations                      | Membership in farmers' / self-help / savings groups | 0.327  | 0.341  |
| <b><u>Pillars<sup>c</sup></u></b>           |   |        |        |
| ABS   | Numeric (latent variable)                           | -0.038 | 0.188  |
| AC  | Numeric (latent variable)                           | -0.032 | 0.901  |
| AST   | Numeric (latent variable)                           | -0.081 | 0.748  |
| SSN   | Numeric (latent variable)                           | -0.283 | 0.627  |
| <b><u>Outcome variables<sup>d</sup></u></b> |   |        |        |
| RCI   | Numeric (latent variable)                           | 65.262 | 10.017 |
| HDDS  | 1-12  | 7.441  | 2.165  |
| Food expenditure per capita                 | US Dollars  | 20.807 | 16.664 |
| Number of observations                      |   | 311    |        |

SD denotes standard deviation. Covariates<sup>a</sup> are control variables that were used in the difference-in-differences model. RCI estimation<sup>b</sup> provides a description of the observed variables that were used to construct each pillar through factor analysis. Pillars<sup>c</sup> shows the values of each of the four pillars (latent variables) that were estimated through factor analysis. Outcome variables<sup>d</sup> are the dependent variables used in the analysis and they include the Resilience Capacity Index (RCI) generated as shown in equation (3), Household Dietary Diversity Score (HDDS) and the food expenditure per capita.

## CHAPTER 6

### Summary, Conclusions, and Policy Implications

While extensive evidence highlights the welfare benefits of agricultural technologies, such as increased yields, higher incomes, and improved food security, adoption rates remain low due to limited access to information among farmers. Extension and advisory services often prioritize men, overlooking women who play a significant role in farming. This study implemented a multi-channel extension campaign to disseminate banana agronomic information encompassing soil fertility and water conservation measures to smallholder farmers, utilizing mass media (radio and video) alongside conventional methods like lecture training, farmer field days, and demonstration trials. Efforts to promote women's participation included the establishment of gender-inclusive groups for knowledge sharing, marketing, savings, and credit access.

The study assessed the effectiveness of audio, audio-visual, and hands-on approaches in delivering information and fostering the adoption of soil-improving and water conservation practices. It specifically compared the impact of audio-visual and hands-on methods with audio-only communication in disseminating knowledge about practices such as manure application, mulching, and trenching. Additionally, it examined how access to information and technology adoption influenced banana yields, sales, household incomes, and food security. The study further evaluated the mediating role of women's empowerment in facilitating the uptake of agricultural technologies. Lastly, it explored the resilience of farming households to climate change impacts and COVID-19-related shocks, highlighting the campaign's role in mitigating these shocks and aiding recovery.

#### 6.1 Summary of empirical methods

This study employed diverse empirical methods to evaluate the impact of a campaign intervention on smallholder household welfare, the role of women's empowerment in promoting the adoption of integrated soil fertility and water conservation practices, and household resilience to the COVID-19 pandemic and climatic shocks. The analytical approaches included ordinary least squares (OLS), analysis of covariance (ANCOVA), difference-in-differences (DID), two-stage least squares (2SLS), generalized random forest (GRF), post-double selection least absolute shrinkage and selection operator

(PDS-LASSO), standard growth regressions, and resilience index measurement and analysis (RIMA), which integrates factor analysis and the multiple indicators multiple causes (MIMIC) model estimated using structural equation modelling (SEM).

OLS, ANCOVA, and DID were applied to estimate the average treatment effects (ATE) of the intervention, focusing on intent-to-treat (ITT) effects. These estimators rely on the assumption that randomized controlled trials mitigate the selection problem, ensuring accurate estimates of intervention effects. With a single baseline and follow-up survey available, incorporating the baseline value of the dependent variable in the analysis gives more precise estimates, hence the ANCOVA analysis is preferred, whereas the DID model served as a robustness check. The 2SLS method estimated the treatment effect on treated participants (TOT), also referred to as local average treatment effects (LATE). GRF addressed treatment heterogeneity, and PDS-LASSO improved covariate selection, reducing risks of analytical bias and *p-hacking*.

In Chapters Two and Three, OLS, DID, and ANCOVA were employed to analyse the campaign's impact on welfare outcomes, particularly ITT effects. Chapter Two focused on the adoption of manure, mulch, trenches, and their combined use, alongside welfare outcomes including yields, commercialization, and household incomes. The analysis compared the effects of audio-visual and hands-on sessions against audio-only methods. Chapter Three extended the analysis to the adoption of an integrated soil fertility and water conservation technology package, real banana income, and food security measures, including the household dietary diversity score (HDDS) and the household food insecurity access scale (HFIAS). In both chapters, 2SLS estimated local average treatment effects, with Chapter Two emphasizing attendance of different sessions and Chapter Three assessing the relationship between technology adoption and food security outcomes.

Chapter Four employed OLS to investigate how women's empowerment mediates the adoption of agricultural technologies in dual households, highlighting the critical role of gender inclusivity in fostering technological uptake. Chapter Five applied RIMA to evaluate rural household resilience to climate change and COVID-19-induced shocks. The key pillars of resilience were identified through factor analysis, while the MIMIC model estimated the resilience capacity index (RCI). The DID model

was used to estimate the impact of the campaign initiative on household resilience depicted by the RCI and food security metrics including HDDS and food expenditure per capita. A standard growth regression was used to assess the influence of the campaign in facilitating the recovery of the households in the face of shocks.

This systematic approach offered robust insights into the campaign's effectiveness in enhancing agricultural technology adoption, improving household welfare, empowering women, and strengthening smallholder households' resilience against unprecedented shocks and uncertainties.

## **6.2 Summary of results**

The study results demonstrate that employing audio-visual and hands-on approaches, alongside audio methods, significantly enhances the adoption of integrated soil fertility and water conservation (ISFWC) practices such as manure, mulch, and trenches among smallholder households. These practices address challenges such as declining soil fertility, drought, and low crop productivity by enhancing soil nutrients, water infiltration, and nutrient and water use efficiency. The campaign-based extension approach led to significant increases in the adoption of individual and combined practices, resulting in higher yields, increased marketed surplus, crop revenues, household incomes, and enhanced food security. Participation in audio-visual and hands-on sessions yielded better outcomes compared to audio-only methods, with the combined communication strategies amplifying technology uptake and contributing to food security, poverty alleviation, and environmental sustainability. Factors such as household head literacy, farmer group membership, and household wealth played critical roles in the adoption of the ISFWC technology package.

The campaign also significantly empowered both men and women, although women's involvement in campaign activities and uptake of practices significantly increased their workload. Women's access to information and participation in (agricultural, credit, and income) decisions and groups significantly influenced the adoption of agricultural technologies that benefit them directly like mulch which reduces the time they spend weeding, and those associated with multiple benefits like the ISFWC package. These findings emphasize the role of gender inclusivity in fostering technology adoption and welfare improvements.

The study results show that ownership of productive assets, credit access, and social networks are key contributors to household resilience. Conversely, limited access to basic services and adaptive capacity were weaker contributors. The study also revealed that health-related shocks had the most severe negative effects on household welfare, exacerbated by restricted mobility, limited access to healthcare, and detrimental coping strategies. However, amidst the shocks, exposure to the agronomy extension campaign significantly improved household welfare, particularly through enhanced dietary quality. Access to information and extension services played a critical role in buffering households against severe shocks, including those caused by mobility restrictions, thereby maintaining their living standards during crises.

### **6.3 Policy Implications**

To improve the effectiveness of agricultural extension systems, information and communication technologies (ICTs) should be integrated for broader outreach. Combining ICTs with traditional methods enables wider dissemination of knowledge, fostering greater awareness and adoption of agricultural practices across diverse farming communities.

Agricultural policies should prioritize expanding and investing in extension services by increasing staff recruitment to enhance efficiency. Furthermore, capacity building within extension services is critical for delivering accurate, detailed information on conservation practices. Training extension staff and developing comprehensive reference materials, like visual aids and manuals ensure consistent messaging, address knowledge gaps, and combat misinformation. These efforts empower farmers with the knowledge needed to adopt sustainable practices effectively.

Localized and inclusive communication strategies are vital for engaging diverse farming populations. Tailoring messages to local dialects and regional information needs while involving farmers as role models through mediums such as dramas, radio shows, and demonstrations can enhance outreach among low-literacy audiences.

Policy efforts should promote gender-transformative reforms in agricultural extension systems to enhance women's knowledge, decision-making autonomy, and access to resources. Holistic approaches

that reduce their work burden, including labour-saving technologies, gender-sensitization programs, and supportive infrastructure, are essential for boosting adoption rates and sustainably improving productivity.

Policymakers should prioritize investments in localized infrastructure to strengthen community resilience. Decentralizing services, particularly health facilities and essential infrastructure, is crucial for improving access in rural areas. Proximity to such services reduces vulnerabilities and enhances the ability of farming households to manage shocks effectively.

Promoting value addition to agricultural produce is crucial for economic diversification, providing alternative income streams and shielding farmers from unforeseen shocks. Integrating value-addition programs into extension services equips farmers with the skills for sustainable livelihoods.

Government support and relief during crises are vital, as rural households often rely on more than their production. Targeted assistance and essential services during shocks can prevent harmful coping mechanisms, promoting resilience, well-being, and long-term food security in rural communities.

## Appendix: Questionnaires

### Appendix 1: Baseline Survey Questionnaire

01. Date of interview: Day: \_\_\_\_Month: \_\_\_\_Year: \_\_\_\_
02. Enumerator Name: \_\_\_\_\_Supervisor Name: \_\_\_\_\_
03. Country: \_\_\_\_\_District: \_\_\_\_\_Sub-County / Division: \_\_\_\_\_  
Parish / Ward: \_\_\_\_\_Village: \_\_\_\_\_
04. Geographical location: Latitude: \_\_\_\_\_° \_\_\_\_\_M \_\_\_\_\_S  
Longitude: \_\_\_\_\_° \_\_\_\_\_M \_\_\_\_\_S  
Elevation [metres]: \_\_\_\_\_
05. Telephone contact of respondent: \_\_\_\_\_
06. Respondent's Name: \_\_\_\_\_
07. Respondent's Age: \_\_\_\_\_years
08. Short description of location eg: next to church: \_\_\_\_\_
09. Language used in interview: \_\_\_\_\_
10. Time: \_\_\_\_\_(Start) \_\_\_\_\_(End)

### SECTION 1: General household information

- 1a. Household Head (HHH) Name: \_\_\_\_\_
- 1b. Gender of HHH: \_\_\_\_\_ [1= Male, 2= Female]
- 1c. Age of HHH (years): \_\_\_\_\_  
1c.(i). HHH Age range if the respondent cannot specify the HHH age: \_\_\_\_\_
- 1d. Marital status of HHH: \_\_\_\_\_ [1= Single, 2= Married, 3= Widowed/divorced/separated]
- 1e. Main occupation of HHH: \_\_\_\_\_ (See Occupation Codes)
- 1f. Main Respondent: \_\_\_\_\_ [1= HH head, 2= Spouse, 3= Son/daughter, 4 = other specify]
- 1g. Gender of Respondent: \_\_\_\_\_ [1= Male, 2= Female]

**Occupation codes:** 1= Farming, 2= Trading, 3= Salary employment, 4= other off-farm employment, 999= None / N/A

**General codes: 991=Other**

**997=No idea**

**999=None/not applicable**

## SECTION 2: Farm household composition and off-farm activities in last 12 months

| HH Member | Name | Position in HH (Code) | Age (yrs) | Gender (Code) | Formal Education. (yrs) | Farming experience (yrs) | Time on-farm (1=Full time 0=Part time) | Off-farm work (Code) | Farmers' group membership (1=yes; 0=No) | Years in farmers' group | Savings & credit group membership (1=Yes; 0=No) | Years in savings & credit group | Self-help group membership (1=Yes; 0=No) | Years in self-help group | Remarks |
|-----------|------|-----------------------|-----------|---------------|-------------------------|--------------------------|--|----------------------|---|-------------------------|---|---------------------------------|--|--------------------------|---------|
| HH1       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH2       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH3       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH4       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH5       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH6       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH7       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH8       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH9       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH10      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH11      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH12      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH13      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH14      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH15      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |

**Position in HH:** 1- head, 2- husband/wife, 3- son/ daughter, 4- son/daughter in law, 5-father/mother, 6-grandchild, 7-sibling, 8-permanently employed worker, 9- sister/brother-inlaw, 991-other, specify;

**Gender:** 1-male, 2-female;

**Off-farm work:** 1-agricultural (off-farm), 2-non-agricultural labour (off-farm), 3-regular employment, government, 4-regular employment, private formal, 5-regular employment, informal, 6-self-employed (no employees), 7-business (with employees), 8-student, 991-other (specify)

### SECTION 3: Plots on the farm in this locality

- Total acreage of land you have: \_\_\_\_\_ (Acres)
- Total acreage of land cultivated in the last 12 months: \_\_\_\_\_ (Acres)
- How many separate plots did you cultivate in the last 12 months? \_\_\_\_\_
- How many types of perennial crops do you cultivate? \_\_\_\_\_
- List them (see perennial crops codes): \_\_\_\_\_

Consider all plots accessed and operated (owned, rented in, rented-out and borrowed) by the household in the last 12 months.

| <b>Plot ID (PID)</b> ( <i>Note: PID to be assigned by enumerator</i> )             |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|
| Plot Name/Nick name  |  |  |  |  |  |  |  |  |
| <b>f.</b> Plot Area (units)  |  |  |  |  |  |  |  |  |
| <b>g.</b> Year acquired  |  |  |  |  |  |  |  |  |
| <b>h.</b> How was it acquired? (see acquisition codes)                             |  |  |  |  |  |  |  |  |
| <b>i.</b> Ownership by gender (see gender codes)                                   |  |  |  |  |  |  |  |  |
| <b>j.</b> User by gender (see gender codes)  |  |  |  |  |  |  |  |  |
| <b>k.</b> Primary use of the plot (see primary use codes)                          |  |  |  |  |  |  |  |  |
| <b>l.</b> Total number of all crops usually grown on the plot during long rains    |  |  |  |  |  |  |  |  |
| <b>m.</b> Total number of all crops usually grown on the plot during short rains   |  |  |  |  |  |  |  |  |
| <b>n.</b> Distance from home to plot (km) <i>for home plot indicate 0km</i>        |  |  |  |  |  |  |  |  |
| <b>o.</b> Walking time from home to plot (minutes)                                 |  |  |  |  |  |  |  |  |
| <b>p.</b> Plot Slope [1= Gentle, 2= Moderate, 3= Steep, 4= No slope 5= Undulating] |  |  |  |  |  |  |  |  |
| <b>q.</b> Extent of erosion on plot [1= High, 2= Moderate, 3= Low, 4= None]        |  |  |  |  |  |  |  |  |

**Plot Acquisition Codes:** 1= Purchased, 2= Rented, 3= Sharecropped, 4= Borrowed in, 5= Received as gift or inheritance, 991=other (specify)

**Gender Codes:** 1= Husband, 2= Wife, 3= Joint (husband & wife), 4- son/ daughter, 5- son/daughter in law, 6-father/mother, 7-grandchild, 8-sibling, 9-permanently employed worker, 10- sister/brother-in-law, 11-Single male, 12-Single female, 991-other, specify;

**Primary Use Codes:** 1=Cultivated (annual crops), 2=Cultivated (perennial crops), 3=Rented-out, 4=Fallow, 5=Grazing land, 6=Woodlot, 7= Homestead, 8= Pasture land, 9 =Fish farming, 10 = Apiary, 999=N/A, 991= Others specify \_\_\_\_\_

**Perennial Crops Codes:** 1=Coffee, 2=Banana, 3=Cocoa, 4=Sugarcane, 991-other, specify;

#### SECTION 4: Cropping patterns

**All Crops production (last 6 months: count 6 months backwards from the interview day and 7-12 months refers to last 7-12 months from the interview day)**

| Plot ID<br>(from<br>sec. 3) | Main crop grown in the<br>last 12 months (Crop<br>code) | Grown by<br>1=husband<br>2=wife<br>3=1&2<br>(both)<br>4=boy child<br>5=girl child<br>6=others | Planting<br>pattern<br>(Pattern<br>codes) | Primary<br>product<br>(Product<br>codes) | Season | Area<br>(acre) | Intercropped<br>(1=yes,<br>0=no) | If yes, main<br>2nd crop?<br>(Crop code) | Give crop<br>proportions<br>for the<br>intercrops | Remarks |
|-----------------------------|---|---|---|--|--------|----------------|----------------------------------|--|---|---------|
|                             |   |   |   |  | 1      |                |                                  |  |   |         |
|                             |   |   |   |  | 2      |                |                                  |  |   |         |
|                             |   |   |   |  | 1      |                |                                  |  |   |         |
|                             |   |   |   |  | 2      |                |                                  |  |   |         |
|                             |   |   |   |  | 1      |                |                                  |  |   |         |
|                             |   |   |   |  | 2      |                |                                  |  |   |         |
|                             |   |   |   |  | 1      |                |                                  |  |   |         |
|                             |   |   |   |  | 2      |                |                                  |  |   |         |
|                             |   |   |   |  | 1      |                |                                  |  |   |         |
|                             |   |   |   |  | 2      |                |                                  |  |   |         |

#### Crop codes:

**Bananas:** 11=Cooking bananas; 12=Sweet bananas; 13=Roasting bananas/plantain; 14=Beer bananas; **Cereals:** 21=Maize; 22=Sorghum; 23=Millet; 24=Rice; 25=Other (specify); **Roots and tubers:** 31=Cassava; 32=Irish potato; 33=Sweet potato; 34=Yam; 35=Other (specify); **Legumes:** 41=Beans; 42=Soybean; 43=Cowpea; 44=Groundnuts; 45= Other (specify); **Cash crops:** 51=Coffee; 52=Tea; 53=Cotton; 54=Sugarcane; 55=Sunflower; 56=Simsim; 57= Other (specify); **Vegetables:** 61=Tomato; 62=Pepper; 63=Pumpkin; 64=Carrot; 65=Onion; 66=Okra; 67=Cauliflower; 68=Cabbage; 69=Amaranth leaves (dodo); 610= Other (specify); **Fruits:** 71=Mango; 72=Pawpaw; 73=Avocado; 74=Jackfruit; 75=Passion fruits; 76=Watermelon; 77=Pineapple; 78=Oranges; 79=Apples; 710= Other (specify); **General:** 81=Pastures; 82=Fallow; 810= Other (specify)

**Planting pattern:** (1=broadcast/random; 0=row-planting (e.g. alleys, basins))

**Primary product:** (1=Grain; 2=Fruit; 3=Leaves; 4=Maize cob; 5=Seed; 6=Tuber; 7=Bulbs; 8=Vegetable; 9=Whole plant; 10=Fish; 11=Fingerlings; 12=Cotton boll; 13=Pods; 14=Pastures; 991=Other (specify), 999=None/ NA)

#### SECTION 5: Utilisation of primary crop products

| Season<br>(code) | Plot ID<br>(from<br>sec. 3) | Crop<br>(code) | Produ<br>ct<br>(code) | Unit used<br>(e.g. sack,<br>tin, basin, | Weight of<br>each unit in<br>kg | Production<br>(total units) | HH<br>food<br>consu | Payment<br>in kind<br>(units) | Livestock<br>feed<br>(units) | Kept as<br>seed<br>(units) | Other<br>deductio<br>ns | Product sales |
|------------------|-----------------------------|----------------|-----------------------|---|---------------------------------|-----------------------------|---------------------|-------------------------------|------------------------------|----------------------------|-------------------------|---------------|
|------------------|-----------------------------|----------------|-----------------------|---|---------------------------------|-----------------------------|---------------------|-------------------------------|------------------------------|----------------------------|-------------------------|---------------|

|  |  |  |  | bunch,<br>basket, etc |  |  | mption<br>(units) |  |  |  | (donatio<br>ns,<br>storage<br>etc)<br>(units) | Quantit<br>y<br>(units) | Unit<br>price<br>(Shs) | Main<br>buyer<br>(codes) | Who makes<br>the decision<br>to sell?<br>1=husband<br>2=wife<br>3=1&2 (both)<br>4=boy child<br>5=girl child<br>6=family<br>7=others | Who decides<br>use of<br>income?<br>1=husband<br>2=wife<br>3=1&2 (both)<br>4=boy child<br>5=girl child<br>6=family<br>7=others |
|--|--|--|--|-----------------------|--|--|-------------------|--|--|--|---|-------------------------|------------------------|--------------------------|---|--|
|  |  |  |  |                       |  |  |                   |  |  |  |   |                         |                        |                          |   |  |
|  |  |  |  |                       |  |  |                   |  |  |  |   |                         |                        |                          |   |  |
|  |  |  |  |                       |  |  |                   |  |  |  |   |                         |                        |                          |   |  |
|  |  |  |  |                       |  |  |                   |  |  |  |   |                         |                        |                          |   |  |
|  |  |  |  |                       |  |  |                   |  |  |  |   |                         |                        |                          |   |  |
|  |  |  |  |                       |  |  |                   |  |  |  |   |                         |                        |                          |   |  |
|  |  |  |  |                       |  |  |                   |  |  |  |   |                         |                        |                          |   |  |
|  |  |  |  |                       |  |  |                   |  |  |  |   |                         |                        |                          |   |  |

**Season:** 1-Main (long rain) season, 2-Short rain season;

**Crop code:**

**Bananas:** 11=Cooking bananas; 12=Sweet bananas; 13=Roasting bananas/plantain; 14=Beer bananas; **Cereals:** 21=Maize; 22=Sorghum; 23=Millet; 24=Rice; 25=Other (specify); **Roots and tubers:** 31=Cassava; 32=Irish potato; 33=Sweet potato; 34=Yam; 35=Other (specify); **Legumes:** 41=Beans; 42=Soybean; 43=Cowpea; 44=Groundnuts; 45= Other (specify); **Cash crops:** 51=Coffee; 52=Tea; 53=Cotton; 54=Sugarcane; 55=Sunflower; 56=Simsim; 57= Other (specify); **Vegetables:** 61=Tomato; 62=Pepper; 63=Pumpkin; 64=Carrot; 65=Onion; 66=Okra; 67=Cauliflower; 68=Cabbage; 69=Amaranth leaves (dodo); 610= Other (specify); **Fruits:** 71=Mango; 72=Pawpaw; 73=Avocado; 74=Jackfruit; 75=Passion fruits; 76=Watermelon; 77=Pineapple; 78=Oranges; 79=Apples; 710= Other (specify); **General:** 81=Pastures; 82=Fallow; 810= Other (specify)

**Product code:** 1=Grain; 2=Fruit; 3=Leaves; 4=Maize cob; 5=Seed; 6=Tuber; 7=Bulbs; 8=Vegetable; 9=Whole plant; 10=Fish; 11=Fingerlings; 12=Cotton boll; 13=Pods; 14=Pastures; 991=Other (specify), 999=None/ NA)

**Main Buyer:** 1-Local market, 2-Neighbour, 3-Retailer, 4-Wholesaler, 5-Broker, 6-Processor, 7-Co-operative, 8-Trader/Middle-man, 991-Other (specify), 999=None/NA

**SECTION 6: Crop residue utilisation**

| Season<br>(code) | Plot<br>ID | Crop<br>(code) | Residue<br>type<br>(code) | Residue left in the plot | Residue transferred from the plot | Residue sales | Remarks |
|------------------|------------|----------------|---------------------------|--------------------------|-----------------------------------|---------------|---------|
|                  |            |                |                           |                          |                                   |               |         |

[illegible]

**Crop codes:**

**Bananas:** 11=Cooking bananas; 12=Sweet bananas; 13=Roasting bananas/plantain; 14=Beer bananas; **Cereals:** 21=Maize; 22=Sorghum; 23=Millet; 24=Rice; 25=Other (specify); **Roots and tubers:** 31=Cassava; 32=Irish potato; 33=Sweet potato; 34=Yam; 35=Other (specify); **Legumes:** 41=Beans; 42=Soybean; 43=Cowpea; 44=Groundnuts; 45= Other (specify); **Cash crops:** 51=Coffee; 52=Tea; 53=Cotton; 54=Sugarcane; 55=Sunflower; 56=Simsim; 57= Other (specify); **Vegetables:** 61=Tomato; 62=Pepper; 63=Pumpkin; 64=Carrot; 65=Onion; 66=Okra; 67=Cauliflower; 68=Cabbage; 69=Amaranth leaves (dodo); 610= Other (specify); **Fruits:** 71=Mango; 72=Pawpaw; 73=Avocado; 74=Jackfruit; 75=Passion fruits; 76=Watermelon; 77=Pineapple; 78=Oranges; 79=Apples; 710= Other (specify); **General:** 81=Pastures; 82=Fallow; 810= Other (specify)

**Residue Codes:** 1=Leaves, 2=Stalks, 3=Husks, 4=Stems, 5=Sawdust, 6=Peelings, 991=Other (Specify), 999=None/NA

**Main Buyer:** 1-Local market, 2-Neighbour, 3-Retailer, 4-Wholesaler, 5-Broker, 6-Processor, 7-Co-operative, 8-Trader/Middle-man, 991-Other (specify), 999=None/NA

**SECTION 7: Activity calendar and labour allocation in other crops' husbandry (except banana) in the last 12 months**

Please tell me about the labour you used on your **OTHER CROPS** in the period. *(Note: Complete individual table per crop grown other than banana)*

**DEFINITION:** ONE PERSON-DAY IS THE NUMBER OF PERSON MULTIPLIED BY THE NUMBER OF DAYS THEY WORK. IF ONE PERSON WORKS 3 DAYS AND TWO OTHER WORK 5 DAYS EACH, THE NUMBER OF PERSON-DAY IS EQUAL TO 13 (= 3 DAYS + 5 DAYS + 5 DAYS)].

[illegible]

| Activity                       | Done in this period?<br>(1=Yes;<br>0=No) | Family labour          |  |             |            | Hired labour           |  |             |            |       |       |                                    |
|--------------------------------|--|------------------------|--|-------------|------------|------------------------|--|-------------|------------|-------|-------|------------------------------------|
|                                |  | No of persons involved |  | Person days | Work hours | No of persons involved |  | Person days | Work hours | Wages | Units | Value for hired labour<br>(UG Shs) |
| Land preparation               |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                    |
|                                |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                    |
| Planting                       |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                    |
|                                |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                    |
| Weeding (Hand, Slash, Spray)   |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                    |
|                                |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                    |
| Irrigating                     |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                    |
|                                |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                    |
| Applying manure or fertilisers |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                    |
|                                |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                    |
| Harvesting                     |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                    |
|                                |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                    |
| Transporting produce           |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                    |
|                                |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                    |
| Others (specify)...            |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                    |
|                                |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                    |

**Crop codes:**

**Bananas:** 11=Cooking bananas; 12=Sweet bananas; 13=Roasting bananas/plantain; 14=Beer bananas; **Cereals:** 21=Maize; 22=Sorghum; 23=Millet; 24=Rice; 25=Other (specify); **Roots and tubers:** 31=Cassava; 32=Irish potato; 33=Sweet potato; 34=Yam; 35=Other (specify); **Legumes:** 41=Beans; 42=Soybean; 43=Cowpea; 44=Groundnuts; 45= Other (specify); **Cash crops:** 51=Coffee; 52=Tea; 53=Cotton; 54=Sugarcane; 55=Sunflower; 56=Simsim; 57= Other (specify); **Vegetables:** 61=Tomato; 62=Pepper; 63=Pumpkin; 64=Carrot; 65=Onion; 66=Okra; 67=Cauliflower; 68=Cabbage; 69=Amaranth leaves (dodo); 610= Other (specify); **Fruits:** 71=Mango; 72=Pawpaw; 73=Avocado; 74=Jackfruit; 75=Passion fruits; 76=Watermelon; 77=Pineapple; 78=Oranges; 79=Apples; 710= Other (specify); **General:** 81=Pastures; 82=Fallow; 810= Other (specify)

# **SECTION 8: Activity calendar and labour allocation in banana husbandry only in the last 12 months**

A). Please tell me about the labour you used on your **BANANA PLOTS** in the period.

**DEFINITION:** ONE PERSON-DAY IS THE NUMBER OF PERSON MULTIPLIED BY THE NUMBER OF DAYS THEY WORK. IF ONE PERSON WORKS 3 DAYS AND TWO OTHER WORK 5 DAYS EACH, THE NUMBER OF PERSON-DAY IS EQUAL TO 13 (= 3 DAYS + 5 DAYS + 5 DAYS)].

| Activity                                 | Done in this period?<br>(1=Yes;<br>0=No) | Family labour          |  |             |            | Hired labour           |  |             |            |       |       |                                 |
|--|--|------------------------|--|-------------|------------|------------------------|--|-------------|------------|-------|-------|---------------------------------|
|  |  | No of persons involved |  | Person days | Work hours | No of persons involved |  | Person days | Work hours | Wages | Units | Value for hired labour (UG Shs) |
| Land preparation                         |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                 |
|  |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                 |
| Digging holes                            |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                 |
|  |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                 |
| Transportation of plantlets              |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                 |
|  |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                 |
| Planting                                 |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                 |
|  |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                 |
| Pruning and/or thinning /<br>desuckering |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                 |
|  |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                 |
| Weeding (Hand, Slash,<br>Spray)          |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                 |
|  |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                 |
| Irrigating                               |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                 |
|  |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                 |
| Applying manure or<br>fertilisers        |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                 |
|  |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                 |
| Harvesting                               |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                 |
|  |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                 |
| Transporting produce                     |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                 |
|  |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                 |
| Others (specify)...                      |  | Male                   |  |             |            | Male                   |  |             |            |       |       |                                 |
|  |  | Female                 |  |             |            | Female                 |  |             |            |       |       |                                 |

B). Please rate the following two statements using a Likert scale of 1 to 5 in terms of labour allocation for banana and annual crops (These statements should be repeated for all months)

| ITEM  | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| The labour I use on <b>BANANAs</b> during this month of ... is ...      |     |     |     |     |     |     |     |     |     |     |     |     |
| The labour I use on <b>ANNUAL CROPS</b> during this month of ... is ... |     |     |     |     |     |     |     |     |     |     |     |     |

**USE CODES:** (1) very low (2) low (3) moderate (4) high (5) very high

### SECTION 9: Integrated soil fertility and pest management practices in banana cropping systems used in the last 12 months

|   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| <b>Plot ID (PID) (from sec. 3)</b>  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>(i). List 3 major pest control practices</b> used on the plot (use PCP codes)                              |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>a.</b> Year establishing the PC practice on this plot  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>b.</b> Source of information on the practice (see codes)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>c.</b> Perceived effectiveness of practice on increasing banana growth and yield in your field (see codes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>d.</b> Are there any PCP that you are aware of but not using in your field? [1= Yes, 0= No]                |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>e.</b> If yes, list them (see PCP codes)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>f.</b> Reasons for not using the practice (see codes)  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**PCP Codes:** 1= Traps, 2= Uprooting, 3= Use of inorganic pesticides, 4=Use of organic/local pesticides, 5=Use of pest repellants, 6 = Fertilizer application, 7= Intercropping, 8= Crop rotation, 9= Use of natural enemies, 10=Use of resistant varieties, 11=Burning, 999=None/N/A, 991= Other specify\_\_\_\_\_

**#(i)b Codes:** 1= Gov't Ext. agent, 2= NGO ext. agent, 3= Fellow farmer, 999=None/N/A, 991= Other specify\_\_\_\_\_

**#(i)c Codes:** 1=Not effective, 2=slightly effective, 3=moderately effective, 4= effective, 5=very effective

**#(i)f Codes:** 1 = Too expensive, 2= Too labor intensive, 3= Not beneficial, 4= Not interested, 999=None/N/A, 991= Other specify\_\_\_\_\_

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| <b>Plot ID (PID) (from sec. 3)</b>   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>(ii). List 3 major soil fertility practices</b> used on the plot (use SFP codes)                                |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>a.</b> Year establishing the SF practice on this plot   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>b.</b> Source of information on the practice (see (i)b codes)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>c.</b> Perceived effectiveness of practice on increasing banana growth and yield in your field (see (i)c codes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>d.</b> Are there any SFP that you are aware of but not using in your field? [1= Yes, 0= No]                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>e.</b> If yes, list them (see SFP codes)  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>f.</b> Reasons for not using the practice (see (i)f codes)  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**SFP Codes:** 1= Intercropping, 2= Agro-forestry, 3= Animal manure application, 4=Compost application, 5=Use of crop residues, 6 = Synthetic fertilizer application, 7 = Fallowing, 8= Crop rotation, 9= Use of leguminous plants, 999=None/N/A, 991= Other specify\_\_\_\_\_

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| <b>Plot ID (PID) (from sec. 3)</b>   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>(iii). List <u>3 major SWC practices</u> on the plot (use SWC codes)</b>  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>a. Year establishing the SWC practice on this plot</b>  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>b. Source of information on this SWC practice (see (i)b codes)</b>  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>c. Proportion of plot conserved or protected by the SWC practice (%)</b>  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>d. Perceived effectiveness of practice on increasing banana growth and yield in your field (see (i)c codes)</b> |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>e. Are there any SWC practices that you are aware of but not using in your field? [1= Yes, 0= No]</b>           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>f. If yes, list them (see SWC codes)</b>  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>g. Reasons for not using the practice (see (i)f codes)</b>  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**SWC Codes:** 1 = Mulching, 2 = Trenches/Diversion channels, 3 = Trash lines, 4 = Contour ploughing, 5 = Grass/and soil bunds, 6 = Grass strips, 7 = Terracing, 8 = Minimum tillage, 9 = Cover crops, 10 = Irrigation, 11 = Fallowing, 12= Crop rotation, 999=None/N/A, 991= Other specify\_\_\_\_\_

(iv) List the banana cultivars in your field over the past 12 months

| Name of Banana variety<br>( Codes A)<br>Refer to country specific codes | Most important desirable attributes<br>(Codes B) |       | Most important undesirable attributes<br>(Codes C) |       | Remarks |
|---|--|-------|--|-------|---------|
|   | Men  | Women | Men  | Women |         |
| 1)  |  |       |  |       |         |
| 2)  |  |       |  |       |         |
| 3)  |  |       |  |       |         |
| 4)  |  |       |  |       |         |
| 5)  |  |       |  |       |         |
| 6)  |  |       |  |       |         |
| 7)  |  |       |  |       |         |
| 8)  |  |       |  |       |         |
| 9)  |  |       |  |       |         |
| 10)   |  |       |  |       |         |
| 11)   |  |       |  |       |         |
| 12)   |  |       |  |       |         |
| 13)   |  |       |  |       |         |
| 14)   |  |       |  |       |         |

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**Codes A (Uganda):**  
**Local:** 1=Ndyabalangira, 2=Nakitembe, 3=Musakala(Nshakala), 4= Mbwarzirume(Mbwairume), 5=Muvubo, 6=Mpologoma, 7=Muyovu, 8=Nakyetengu, 9=Nakabululu, 10=Kibuzi, 11=Muzira Nyama, 12=Nakawere, 13=Kisansa, 14=Nyamwezi, 15=Nakinyika, 16=Bogaya, 17=Sukali Ndiizi, 18=Kayinja, 19= Mshale, 20=Cavandish  
**Improved:** 21=M2, 22=M9(Kiwangaazi), 23=Fhia 1 24=Fhia 17 25=Fhia 25, 26=Yangambi KM5, 27= Psang Ceylani, 991=Others specify:-----

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**Codes A (Tanzania):**  
**Local:** 28= Nshakara, 29= Inamambo, 30= Ngonja, 31= Mshare, 32= Mbwairuma, 33= Sukari ndizi, 34= Kisubi, 35= Njoge, 36= Ndyali, 37= Ifanaya, 38= Malindi, 39= Nyoya, 40= Enjubo, 41= Mtwishe, 42= Nshansha, 43= Entobe, 44= Pazi, 45= Grand naine, 46= Enshakara, 47= Ensenene, 48=Entalagaza  
**Improved:** 49= FHIA 17, 50= FHIA 23, 51= Yangabi KM5, 52= Williams, 991=Others specify:-----  
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**Codes B:** : 1=Resistance to pests & diseases, 2=Tolerance to drought, 3=Tolerance to poor soils, 4=short Maturity period, 5=Bunch size, 6=Finger size, 7=Skin colour, 8=Sucker production, 9=Leafiness (leaf production), 10=low Plant height, 11=Resistance to wind, 12=Shelf life /durability after harvest, 13=Easy to peel, 14=Low sappiness, 15=Cooking time, 16=Food colour when cooked, 17=Texture (Softness) when cooked, 18=Heat Retention, 19=Flavour, 20=Taste, 991=other specify -----

**Codes C:** 1=susceptible to pests & diseases, 2=Prone to drought/moisture stress, 3=Prone to poor soils, 4=long maturity period, 5=small bunch size, 6=small Fingers , 7= unpleasant skin colour, 8=poor suckering, 9=low leafiness (leaf production), 10=High Plant height, 11=prone to wind damage, 12=low Shelf life /durability after harvest, 13=hard to peel, 14=High sappiness, 15=long Cooking time, 16=Food colour when cooked, 17=Texture (Softness) when cooked, 18=low Heat Retention, 19=unpleasant Flavour, 20=poor Taste, 991=other specify -----

- a. What was the source of the planting materials for the improved varieties? (**Only answer if improved varieties are given**)
- b. If you did not plant any improved varieties in the past 12 months, would you be willing to try out improved varieties? (**1=yes; 0=no**)
- c. If yes, which ones? (**Use improved varieties codes**)
- d. Which traits would you consider most highly in selecting improved banana varieties to plant in your field? (**Use Codes B above**)

**SECTION 10: Ranking of crop enterprises as source of income from crop sales, food for household consumption, labour requirement and, land requirement in the last 12 months:**

|    | Most important for sales | Most important for household consumption | Taking most of the labour | Taking most of the land | Remarks |
|----|--------------------------|--|---------------------------|-------------------------|---------|
| 1  |                          |  |                           |                         |         |
| 2  |                          |  |                           |                         |         |
| 3  |                          |  |                           |                         |         |
| 4  |                          |  |                           |                         |         |
| 5  |                          |  |                           |                         |         |
| 6  |                          |  |                           |                         |         |
| 7  |                          |  |                           |                         |         |
| 8  |                          |  |                           |                         |         |
| 9  |                          |  |                           |                         |         |
| 10 |                          |  |                           |                         |         |

**SECTION 11: Livestock in the last 12 months**

**11.1. Do you have livestock? (1 = yes ; 0 = No)**

**11.2. If yes, list them..... (see livestock codes)**

**Livestock Codes:** 1-Cattle, 2-Buffaloe, 3-Goat, 4-Sheep, 5-Pig, 6-Chicken, 7-Quail, 8-Duck, 9-Goose, 10-Turkey, 11-Guinea fowl, 12-Pigeon, 13-Rabbit, 14-Guinea pig, 15-Donkey, 16-Mule, 17-Horse, 18-Bee hive, 991-Other (specify)

**11.3. Non-ruminant livestock species in the last 12 months:**

| Livestock (code) | Gender ownership (code) | Total number of animals | Adult females | Adult males | Young | Remarks |
|------------------|-------------------------|-------------------------|---------------|-------------|-------|---------|
|                  |                         |                         |               |             |       |         |
|                  |                         |                         |               |             |       |         |
|                  |                         |                         |               |             |       |         |
|                  |                         |                         |               |             |       |         |
|                  |                         |                         |               |             |       |         |
|                  |                         |                         |               |             |       |         |
|                  |                         |                         |               |             |       |         |
|                  |                         |                         |               |             |       |         |

**Livestock:** 1-Chicken, 2-Quails, 3-Ducks, 4-Turkeys, 5-Guinea fowl, 6-Guinea pigs, 7-Geese, 8-Pigeon, 9-Rabbits, 10-Donkeys, 11-Horses, 12-Bee hives, 991-Other;

**Gender Codes:** 1= Husband, 2= Wife, 3= Joint (husband & wife), 4- son/ daughter, 5- son/daughter in law, 6- father/mother, 7-grandchild, 8-sibling, 9-permanently employed worker, 10- sister/brother-in-law, 11-Single male, 12-Single female, 991-other, specify;

**SECTION 12: Ruminant livestock species plus pigs in the last 12 months:**

|    |                   |                 |                          |   |                     |                   |                     | only for adult females |                               |   |                                    |                                |  |  |  |   |
|----|-------------------|-----------------|--------------------------|---|---------------------|-------------------|---------------------|------------------------|-------------------------------|---|------------------------------------|--------------------------------|--|--|--|---|
|    |                   |                 |                          |   | age range           |                   | ownership           | pregnant<br>now [no.]  | being milke<br>d now<br>[no.] | on-farm average value within category       |                                    |                                |  |  |  | used<br>for animal<br>traction<br>n [no.] |
| ID | species<br>(code) | breed<br>(code) | no. of<br>animals<br>NOW |   | youngest<br>[month] | oldest<br>[month] | by gender<br>(code) |                        |                               | Av.<br>time<br>between<br>births<br>[month] | offspring<br>per<br>birth<br>[no.] | only for dairy animals         |  |  |  |   |
|    |                   |                 | M                        | F |                     |                   |                     |                        |                               |   |                                    | lactation<br>length<br>[month] | Av.<br>milk<br>yield<br>max<br>[ltr/d] | Av.<br>milk<br>suckled<br>at<br>max<br>[%] | Av.<br>milk<br>yield<br>min<br>[ltr/d] |   |
| 1  |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 2  |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 3  |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 4  |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 5  |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 6  |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 7  |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 8  |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 9  |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 10 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 11 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 12 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 13 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 14 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 15 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 16 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 17 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 18 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 19 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 20 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |
| 21 |                   |                 |                          |   |                     |                   |                     |                        |                               |   |                                    |                                |  |  |  |   |

**Species:** 1-Cattle, 2-Bufferaloe, 3- Goat, 4- Sheep, **5-Pig**; 991-other, specify

**Breed:** 1- local, 2- cross/improved, 3- pure/exotic;

**Gender Codes:** 1= Husband, 2= Wife, 3= Joint (husband & wife), 4- son/ daughter, 5- son/daughter in law, 6-father/mother, 7-grandchild, 8-sibling, 9-permanently employed worker, 10- sister/brother-in-law, 11-Single male, 12-Single female, 991-other, specify

| ID | changes<br>in Nos.<br>within<br>last 12<br>months?<br>1=yes<br>0=no | In                                 |               |                                     |                         |                      | out             |                               |                        |            |                             |                                     | Remarks |
|----|---|------------------------------------|---------------|-------------------------------------|-------------------------|----------------------|-----------------|-------------------------------|------------------------|------------|-----------------------------|-------------------------------------|---------|
|    |   | total in 12<br>months ago<br>[no.] | born<br>[no.] | gift/<br>dowry /<br>shared<br>[no.] | pur-<br>chased<br>[no.] | total paid<br>(Shs.) | deaths<br>[no.] | gift/ dowry / shared<br>[no.] | con-<br>sumed<br>[no.] | sold [no.] | total<br>received<br>[Shs.] | other out<br>(e.g. stolen)<br>[no.] |         |
| 1  |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 2  |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 3  |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 4  |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 5  |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 6  |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 7  |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 8  |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 9  |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 10 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 11 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 12 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 13 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 14 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 15 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 16 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 17 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 18 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 19 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 20 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |
| 21 |   |                                    |               |                                     |                         |                      |                 |                               |                        |            |                             |                                     |         |

### SECTION 13: Livestock products in the last 12 months:

|               |                |                  |                     | Production            | Sales                 |                  |                    |                               |                   | HH human consumption  | Other (e.g. gift, donation stored etc.) quantity [prod. code] | Remarks |
|---------------|----------------|------------------|---------------------|-----------------------|-----------------------|------------------|--------------------|-------------------------------|-------------------|-----------------------|---|---------|
| Season (code) | Product (code) | Livestock (code) | Data period (codes) | quantity [prod. code] | quantity [prod. code] | Unit cost (Shs.) | total value [Shs.] | income control, gender (code) | main buyer (code) | quantity [prod. code] | quantity [prod. code]   |         |
|               |                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|               |                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|               |                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|               |                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|               |                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|               |                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|               |                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|               |                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |

**Season:** 1=Main (long rain) season, 2=Short rain season

**Data Period Codes:** 1=Daily; 2=Whole season

**Product / Service:** 1-Milk [ltr], 2-Curd/yoghurt [kg], 3-Butter [kg], 4-Ghee [kg], 5-Cheese [kg], 6-Khoya/Chena [kg], 7-Meat [kg], 8-Eggs [no.], 9-Whole animal (no.), 10-Hair [kg], 11-Hides/skin [no.], 12-Honey [kg], 13-Beeswax [kg], 14-Wool [kg], 15-Manure [kg]; 16-Male service (bull, goat, pig, etc); 999-None/NA, 991-Other, specify;

**Livestock:** 1-Cattle, 2-Buffaloe, 3-Goat, 4-Sheep, 5-Pig, 6-Chicken, 7-Quail, 8-Duck, 9-Goose, 10-Turkey, 11-Guinea fowl, 12-Pigeon, 13-Rabbit, 14-Guinea pig, 15-Donkey, 16-Mule, 17-Horse, 18-Bee hive, 991-Other (specify)

**Gender Codes:** 1= Husband, 2= Wife, 3= Joint (husband & wife), 4- son/ daughter, 5- son/daughter in law, 6-father/mother, 7-grandchild, 8-sibling, 9-permanently employed worker, 10- sister/brother-in-law, 11-Single male, 12-Single female, 991-other, specify

**Main Buyer:** 1-Local market, 2-Neighbour, 3-Retailer, 4-Wholesaler, 5-Broker, 6-Processor, 7-Co-operative, 8-Trader/Middle-man, 999-None/NA, 991-Other (specify)

#### SECTION 14: Livestock feeding:

| Season (code) | Livestock (IDs) | ) Feed (code, multiple) | Form (code, multiple) | Source (code, multiple) | Purchased [kg] | Total purchase cost (Shs) | Quantity fed [kg/d] | Days fed in a week [no.] | Number of hours spent feeding per day [no.] | Feeding period in season [mo] | Estimated total market value [Shs] | Other costs (e.g. transport) [Shs] | Notes |
|---------------|-----------------|-------------------------|-----------------------|-------------------------|----------------|---------------------------|---------------------|--------------------------|---|-------------------------------|------------------------------------|------------------------------------|-------|
|               |                 |                         |                       |                         |                |                           |                     |                          |   |                               |                                    |                                    |       |
|               |                 |                         |                       |                         |                |                           |                     |                          |   |                               |                                    |                                    |       |
|               |                 |                         |                       |                         |                |                           |                     |                          |   |                               |                                    |                                    |       |
|               |                 |                         |                       |                         |                |                           |                     |                          |   |                               |                                    |                                    |       |
|               |                 |                         |                       |                         |                |                           |                     |                          |   |                               |                                    |                                    |       |
|               |                 |                         |                       |                         |                |                           |                     |                          |   |                               |                                    |                                    |       |
|               |                 |                         |                       |                         |                |                           |                     |                          |   |                               |                                    |                                    |       |
|               |                 |                         |                       |                         |                |                           |                     |                          |   |                               |                                    |                                    |       |
|               |                 |                         |                       |                         |                |                           |                     |                          |   |                               |                                    |                                    |       |
|               |                 |                         |                       |                         |                |                           |                     |                          |   |                               |                                    |                                    |       |
|               |                 |                         |                       |                         |                |                           |                     |                          |   |                               |                                    |                                    |       |

**Season:** 1-Main (long rain) season, 2-Short rain season

**Feed:** **1=Dry fodder** (-Maize stover, Wheat straw, Rice straw, Sorghum stover, Millet stover, Pulse straw, Sunflower stalks, Hay); **2=Pasture legumes** (Calliandra, Lucerne, Berseem, Brachiaria, Sesbania, Leucaena, Gliricidia); **3=Pasture grasses** (Napier grass, Rhodes grass, Guatemala grass, Clover); **4=Green fodder** (Maize stover, Sorghum stover, Millet stover, Sweet potato vine, Banana trunk/leaves, Sugar cane tops); **5=Concentrates** (Wheat bran, Maize bran, Rice bran, Bean cover, Pulse pods, Dairy meal, Cotton seed cake, Soybean cake, Sunflower cake, Linseed cake, Molasses, Brewery by-products); **6=HH food refuse**; **991=Other (specify)**

**Form:** 1-Fresh, 2-Dried, 3-Grazed, 4-Silage; 5-Concentrates; 991-other (specify)

**Sources:** 1-farm, 2-purchased, 3-collected, 4-gift, 5-grazed off farm; 991-Other (specify)

### SECTION 15: Dung production and utilization in the last 12 months:

## Livestock location

[illegible]

**Livestock:** 1-Cattle, 2-Buffaloe, 3-Goat, 4-Sheep, 5-Pig, 6-Chicken, 7-Quail, 8-Duck, 9-Goose, 10-Turkey, 11-Guinea fowl, 12-Pigeon, 13-Rabbit, 14-Guinea pig, 15-Donkey, 16-Mule, 17-Horse, 18-Bee hive, 991-Other (specify)

| Livestock<br>(codes)    | Dung Utilization       |                                     | Dung Utilization |            |              |        |        |      |          |       | Sales Decisions   |  | Remarks |
|-------------------------|------------------------|-------------------------------------|------------------|------------|--------------|--------|--------|------|----------|-------|---|--|---------|
|                         |                        |                                     | Fuel/repellant   | Fertilizer | Construction | Biogas | Wasted | Sold | Revenues | Total | Who makes<br>the decision<br>to sell?<br>1=husband<br>2=wife<br>3=1&2 (both)<br>4=boy child<br>5=girl child<br>6=others | Who<br>decides use<br>of income?<br>1=husband<br>2=wife<br>3=1&2 (both)<br>4=boy child<br>5=girl child<br>6=others |         |
|                         | Location               | Amount Collected<br>(Include Units) | %                | %          | %            | %      | %      |      | (Shs)    | %     |   |  |         |
| Main (long) Rain Season |                        |                                     |                  |            |              |        |        |      |          |       |   |  |         |
|                         | Stable / Poultry house |                                     |                  |            |              |        |        |      |          | 100   |   |  |         |
|                         | Yard / Kraal           |                                     |                  |            |              |        |        |      |          | 100   |   |  |         |
|                         | Crop field             |                                     |                  |            |              |        |        |      |          | 100   |   |  |         |
|                         | Grazing land           |                                     |                  |            |              |        |        |      |          | 100   |   |  |         |
|                         | outside own farm       |                                     |                  |            |              |        |        |      |          | 100   |   |  |         |
| Short Rain Season       |                        |                                     |                  |            |              |        |        |      |          |       |   |  |         |
|                         | Stable / Poultry house |                                     |                  |            |              |        |        |      |          | 100   |   |  |         |
|                         | Yard / Kraal           |                                     |                  |            |              |        |        |      |          | 100   |   |  |         |
|                         | Crop field             |                                     |                  |            |              |        |        |      |          | 100   |   |  |         |
|                         | Grazing land           |                                     |                  |            |              |        |        |      |          | 100   |   |  |         |
|                         | outside own farm       |                                     |                  |            |              |        |        |      |          | 100   |   |  |         |

## SECTION 16: Farm assets

| Name of asset                           | Do you own<br>1 = yes<br>0 = no | Total number<br>owned (No.) | Access/Use<br>1.Woman 2.Man<br>3.Both 4.Other | Ownership<br>1.Woman 2.Man<br>3.Both 4.Other | Control of Usage<br>1.Woman 2.Man<br>3.Both 4.Other | Approximate today's<br>value<br>(UG. Shs) | Notes |
|---|---------------------------------|-----------------------------|---|--|---|---|-------|
| <b>Transport</b>                        |                                 |                             |   |  |   |   |       |
| Car/Truck                               |                                 |                             |   |  |   |   |       |
| Motorcycle                              |                                 |                             |   |  |   |   |       |
| Bicycle                                 |                                 |                             |   |  |   |   |       |
| Cart (animal drawn)                     |                                 |                             |   |  |   |   |       |
| <b>Farm</b>                             |                                 |                             |   |  |   |   |       |
| Hoes                                    |                                 |                             |   |  |   |   |       |
| Spades/shovel                           |                                 |                             |   |  |   |   |       |
| Ploughs                                 |                                 |                             |   |  |   |   |       |
| Sprayer<br>pump/Knapsack                |                                 |                             |   |  |   |   |       |
| Water pump                              |                                 |                             |   |  |   |   |       |
| Wheelbarrow                             |                                 |                             |   |  |   |   |       |
| Water tank                              |                                 |                             |   |  |   |   |       |
| Tractor                                 |                                 |                             |   |  |   |   |       |
| Stores / silos                          |                                 |                             |   |  |   |   |       |
| Zero grazing units                      |                                 |                             |   |  |   |   |       |
| Incubator                               |                                 |                             |   |  |   |   |       |
| Mills(maize,rice,coffee)                |                                 |                             |   |  |   |   |       |
| Chaff cutter                            |                                 |                             |   |  |   |   |       |
| Sickle                                  |                                 |                             |   |  |   |   |       |
| Panga                                   |                                 |                             |   |  |   |   |       |
| Pruning knife                           |                                 |                             |   |  |   |   |       |
| Axe                                     |                                 |                             |   |  |   |   |       |
| Rake                                    |                                 |                             |   |  |   |   |       |
| Forked hoe                              |                                 |                             |   |  |   |   |       |
| Slasher                                 |                                 |                             |   |  |   |   |       |
| Spear                                   |                                 |                             |   |  |   |   |       |
| <b>Buildings (leave out Home house)</b> |                                 |                             |   |  |   |   |       |
|   |                                 |                             |   |  |   |   |       |
|   |                                 |                             |   |  |   |   |       |
|   |                                 |                             |   |  |   |   |       |
| <b>Communication</b>                    |                                 |                             |   |  |   |   |       |
| Phone                                   |                                 |                             |   |  |   |   |       |
| Radio                                   |                                 |                             |   |  |   |   |       |
| Television                              |                                 |                             |   |  |   |   |       |
| <b>Others</b>                           |                                 |                             |   |  |   |   |       |
|   |                                 |                             |   |  |   |   |       |
|   |                                 |                             |   |  |   |   |       |
|   |                                 |                             |   |  |   |   |       |

## SECTION 17: Off-farm income in the last 12 months

[illegible]

**Income source:** 1- agricultural labour (off-farm), 2- non-agricultural labour (off-farm), 3-regular employment, government, 4-regular employment, private formal, 5-regular employment, informal, 6-self-employed (no employees), 7-business (with employees), 8-remittances, 9-income from land, 10-interest, 11-savings, 12-revolving fund, 13-pension, 14-rental income, 999-None/NA, 991-other, specify;

**Gender Codes:** 1= Husband, 2= Wife, 3= Joint (husband & wife), 4- son/ daughter, 5- son/daughter in law, 6- father/mother, 7-grandchild, 8-sibling, 9-permanently employed worker, 10- sister/brother-in-law, 11-Single male, 12-Single female, 991-other, specify

**SECTION 18: Household expenses in the last 12 months**

*(Note: If the respondent cannot breakdown the expenditure, capture the figure in the "total cost" column)*

| Expense item  | Frequency (codes) | Quantity | Units | Unit cost (Shs.) | Total Cost (Shs) | Notes |
|---|-------------------|----------|-------|------------------|------------------|-------|
| <b>Housing</b>  |                   |          |       |                  |                  |       |
| 11-House rent   |                   |          |       |                  |                  |       |
| 12-Water  |                   |          |       |                  |                  |       |
| 13-Hh fuel (Fire wood, Charcoal, Kerosene, LPG, Biogas) |                   |          |       |                  |                  |       |
| 14-Electricity  |                   |          |       |                  |                  |       |
| 19-Other housing expenses                               |                   |          |       |                  |                  |       |
| <b>Personal</b>   |                   |          |       |                  |                  |       |
| 21-Soap & other toiletries                              |                   |          |       |                  |                  |       |
| 22-Batteries (dry)                                      |                   |          |       |                  |                  |       |
| 23-Newspapers   |                   |          |       |                  |                  |       |
| 29-Other personal                                       |                   |          |       |                  |                  |       |
| <b>Transport &amp; Communication</b>                    |                   |          |       |                  |                  |       |
| 31-Transport fuel (petrol, diesel)                      |                   |          |       |                  |                  |       |
| 32-Public transport charges                             |                   |          |       |                  |                  |       |
| 33-Post (Stamps, envelopes)                             |                   |          |       |                  |                  |       |
| 34-Phone  |                   |          |       |                  |                  |       |
| 35-Airtime  |                   |          |       |                  |                  |       |
| 39-Other  |                   |          |       |                  |                  |       |
| <b>Health</b>   |                   |          |       |                  |                  |       |
| 41-Doctor consultation                                  |                   |          |       |                  |                  |       |
| 42-Medicine   |                   |          |       |                  |                  |       |
| 43-Hospital/clinic                                      |                   |          |       |                  |                  |       |
| 44-Traditional health service                           |                   |          |       |                  |                  |       |
| 49-Other health expenses                                |                   |          |       |                  |                  |       |
| <b>Other categories</b>                                 |                   |          |       |                  |                  |       |

| Expense item  | Frequency (codes) | Quantity | Units | Unit cost (Shs.) | Total Cost (Shs) | Notes |
|---|-------------------|----------|-------|------------------|------------------|-------|
| 51-Other services (sports, theatre, laundry, domestic help, barber etc.)        |                   |          |       |                  |                  |       |
| 61-Clothing & foot wear (exclude uniform)                                       |                   |          |       |                  |                  |       |
| 71-Furniture  |                   |          |       |                  |                  |       |
| 81-Hh appliances  |                   |          |       |                  |                  |       |
| 91-Glass & tableware  |                   |          |       |                  |                  |       |
| 101-Education (all e.g. fees, uniform, etc.)                                    |                   |          |       |                  |                  |       |
| 111-Social and other services (functions, ceremonies, funerals, insurance etc.) |                   |          |       |                  |                  |       |
| <b>Non-consumptive expenses</b>   |                   |          |       |                  |                  |       |
| 121-Remittance payments   |                   |          |       |                  |                  |       |
| 122-Interest payments   |                   |          |       |                  |                  |       |
| 123-Pension & social security payments  |                   |          |       |                  |                  |       |
| 124-Tax payments (income, property, local service, ground rent)                 |                   |          |       |                  |                  |       |
| 129-Other non-consumptive expenses  |                   |          |       |                  |                  |       |
| <b>Salaries</b>   |                   |          |       |                  |                  |       |
| 131-Salaries paid to permanently employed workers                               |                   |          |       |                  |                  |       |
| <b>Other livestock expenses (exc. Ruminants &amp; pigs)</b>                     |                   |          |       |                  |                  |       |
| 139-Expenses for other livestock (excl ruminants & pigs) + dogs, cats, etc      |                   |          |       |                  |                  |       |

**Frequency codes:** 1-Daily, 2-weekly, 3-monthly, 4-every 2 weeks, 5-every 2 months, 6-every 6 months, 7-quarterly, 8-annually, 9-bi-annually

## SECTION 19: Household Consumption Expenditure

19.1. On average, how many people were present in this household in the last 7 days (one week ago)? In this section children are defined as less than 18 years.

| Household Members |               |               |                 | Visitors    |               |               |                 |
|-------------------|---------------|---------------|-----------------|-------------|---------------|---------------|-----------------|
| Male adults       | Female adults | Male children | Female children | Male adults | Female adults | Male children | Female children |
|                   |               |               |                 |             |               |               |                 |

19.2 Consumption (Food, Beverage, and Tobacco) (During the Last 7 Days) (Note: Value = Price (market / farm gate) × Qty)

| Item Description       | Item consumed<br>1=Yes<br>0=No | Unit of Quantity | Consumption out of Purchases |         |                |         | Consumption out of home produce |         | Received in-kind/Free |          | Av. Market Price | Av. Farm gate price |
|------------------------|--------------------------------|------------------|------------------------------|---------|----------------|---------|---------------------------------|---------|-----------------------|----------|------------------|---------------------|
|                        |                                |                  | Household                    |         | Away from home |         |                                 |         |                       |          |                  |                     |
|                        |                                |                  | Qty                          | Value   | Qty            | Value   | Qty                             | Value   | Qty                   | Value    |                  |                     |
| 1                      | 2                              | 3                | 4                            | 5       | 6              | 7       | 8                               | 9       | 10                    | 11       | 12               | 13                  |
| Matoke (Bunch)         | 101                            | HH101F3          | HH101F4                      | HH101F5 |                |         | HH101F8                         | HH101F9 | HH101F10              | HH101F11 | HH101F12         | HH101F13            |
| Matoke (Cluster)       | 102                            | HH102F3          | HH102F4                      | HH102F5 |                |         | HH102F8                         | HH102F9 | HH102F10              | HH102F11 | HH102F12         | HH102F13            |
| Matoke (Heap)          | 103                            | HH103F3          | HH103F4                      | HH103F5 |                |         | HH103F8                         | HH103F9 | HH103F10              | HH103F11 | HH103F12         | HH103F13            |
| Matoke (Others)        | 104                            | HH104F3          | HH104F4                      | HH104F5 |                |         | HH104F8                         | HH104F9 | HH104F10              | HH104F11 | HH104F12         | HH104F13            |
| Sweet Potatoes (Fresh) | 105                            | HH105F3          | HH105F4                      | HH105F5 | HH105F6        | HH105F7 | HH105F8                         | HH105F9 | HH105F10              | HH105F11 | HH105F12         | HH105F13            |
| Sweet Potatoes (Dry)   | 106                            | HH106F3          | HH106F4                      | HH106F5 |                |         | HH106F8                         | HH106F9 | HH106F10              | HH106F11 | HH106F12         | HH106F13            |
| Cassava (Fresh)        | 107                            | HH107F3          | HH107F4                      | HH107F5 | HH107F6        | HH107F7 | HH107F8                         | HH107F9 | HH107F10              | HH107F11 | HH107F12         | HH107F13            |
| Cassava (Dry/Flour)    | 108                            | HH108F3          | HH108F4                      | HH108F5 |                |         | HH108F8                         | HH108F9 | HH108F10              | HH108F11 | HH108F12         | HH108F13            |
| Irish Potatoes         | 109                            | HH109F3          | HH109F4                      | HH109F5 |                |         | HH109F8                         | HH109F9 | HH109F10              | HH109F11 | HH109F12         | HH109F13            |
| Rice                   | 110                            | HH110F3          | HH110F4                      | HH110F5 |                |         | HH110F8                         | HH110F9 | HH110F10              | HH110F11 | HH110F12         | HH110F13            |
| Maize (grains)         | 111                            | HH111F3          | HH111F4                      | HH111F5 |                |         | HH111F8                         | HH111F9 | HH111F10              | HH111F11 | HH111F12         | HH111F13            |
| Maize (cobs)           | 112                            | HH112F3          | HH112F4                      | HH112F5 | HH112F6        | HH112F7 | HH112F8                         | HH112F9 | HH112F10              | HH112F11 | HH112F12         | HH112F13            |
| Maize (flour)          | 113                            | HH113F3          | HH113F4                      | HH113F5 |                |         | HH113F8                         | HH113F9 | HH113F10              | HH113F11 | HH113F12         | HH113F13            |
| Bread                  | 114                            | HH114F3          | HH114F4                      | HH114F5 | HH114F6        | HH114F7 | HH114F8                         | HH114F9 | HH114F10              | HH114F11 | HH114F12         | HH114F13            |

| Item Description       | Item consumed<br>1=Yes<br>0=No | Unit of Quantity | Consumption out of Purchases |         |                |         | Consumption out of home produce |         | Received in-kind/Free |          | Av. Market Price | Av. Farm gate price |
|------------------------|--------------------------------|------------------|------------------------------|---------|----------------|---------|---------------------------------|---------|-----------------------|----------|------------------|---------------------|
|                        |                                |                  | Household                    |         | Away from home |         |                                 |         |                       |          |                  |                     |
|                        |                                |                  | Qty                          | Value   | Qty            | Value   | Qty                             | Value   | Qty                   | Value    |                  |                     |
| 1                      | 2                              | 3                | 4                            | 5       | 6              | 7       | 8                               | 9       | 10                    | 11       | 12               | 13                  |
| Millet                 | 110                            | HH110F3          | HH110F4                      | HH110F5 |                |         | HH110F8                         | HH110F9 | HH110F10              | HH110F11 | HH110F12         | HH110F13            |
| Sorghum                | 116                            | HH116F3          | HH116F4                      | HH116F5 |                |         | HH116F8                         | HH116F9 | HH116F10              | HH116F11 | HH116F12         | HH116F13            |
| Beef                   | 117                            | HH117F3          | HH117F4                      | HH117F5 | HH117F6        | HH117F7 | HH117F8                         | HH117F9 | HH117F10              | HH117F11 | HH117F12         | HH117F13            |
| Pork                   | 118                            | HH118F3          | HH118F4                      | HH118F5 | HH118F6        | HH118F7 | HH118F8                         | HH118F9 | HH118F10              | HH118F11 | HH118F12         | HH118F13            |
| Goat Meat              | 119                            | HH119F3          | HH119F4                      | HH119F5 | HH119F6        | HH119F7 | HH119F8                         | HH119F9 | HH119F10              | HH119F11 | HH119F12         | HH119F13            |
| Other Meat             | 120                            | HH120F3          | HH120F4                      | HH120F5 | HH120F6        | HH120F7 | HH120F8                         | HH120F9 | HH120F10              | HH120F11 | HH120F12         | HH120F13            |
| Chicken                | 121                            | HH121F3          | HH121F4                      | HH121F5 | HH121F6        | HH121F7 | HH121F8                         | HH121F9 | HH121F10              | HH121F11 | HH121F12         | HH121F13            |
| Fresh Fish             | 122                            | HH122F3          | HH122F4                      | HH122F5 | HH122F6        | HH122F7 | HH122F8                         | HH122F9 | HH122F10              | HH122F11 | HH122F12         | HH122F13            |
| Dry/ Smoked fish       | 123                            | HH123F3          | HH123F4                      | HH123F5 | HH123F6        | HH123F7 | HH123F8                         | HH123F9 | HH123F10              | HH123F11 | HH123F12         | HH123F13            |
| Eggs                   | 124                            | HH124F3          | HH124F4                      | HH124F5 | HH124F6        | HH124F7 | HH124F8                         | HH124F9 | HH124F10              | HH124F11 | HH124F12         | HH124F13            |
| Fresh Milk             | 125                            | HH125F3          | HH125F4                      | HH125F5 | HH125F6        | HH125F7 | HH125F8                         | HH125F9 | HH125F10              | HH125F11 | HH125F12         | HH125F13            |
| Infant Formula Foods   | 126                            | HH126F3          | HH126F4                      | HH126F5 |                |         | HH126F8                         | HH126F9 | HH126F10              | HH126F11 | HH126F12         | HH126F13            |
| Cooking oil            | 127                            | HH127F3          | HH127F4                      | HH127F5 |                |         | HH127F8                         | HH127F9 | HH127F10              | HH127F11 | HH127F12         | HH127F13            |
| Ghee                   | 128                            | HH128F3          | HH128F4                      | HH128F5 |                |         | HH128F8                         | HH128F9 | HH128F10              | HH128F11 | HH128F12         | HH128F13            |
| Margarine, Butter, etc | 129                            | HH129F3          | HH129F4                      | HH129F5 | HH129F6        | HH129F7 | HH129F8                         | HH129F9 | HH129F10              | HH129F11 | HH129F12         | HH129F13            |
| Passion Fruits         | 130                            | HH130F3          | HH130F4                      | HH130F5 |                |         | HH130F8                         | HH130F9 | HH130F10              | HH130F11 | HH130F12         | HH130F13            |
| Sweet Bananas          | 131                            | HH131F3          | HH131F4                      | HH131F5 | HH131F6        | HH131F7 | HH131F8                         | HH131F9 | HH131F10              | HH131F11 | HH131F12         | HH131F13            |
| Mangos                 | 132                            | HH132F3          | HH132F4                      | HH132F5 | HH132F6        | HH132F7 | HH132F8                         | HH132F9 | HH132F10              | HH132F11 | HH132F12         | HH132F13            |
| Oranges                | 133                            | HH133F3          | HH133F4                      | HH133F5 | HH133F6        | HH133F7 | HH133F8                         | HH133F9 | HH133F10              | HH133F11 | HH133F12         | HH133F13            |
| Other Fruits           | 134                            | HH134F3          | HH134F4                      | HH134F5 | HH134F6        | HH134F7 | HH134F8                         | HH134F9 | HH134F10              | HH134F11 | HH134F12         | HH134F13            |
| Onions                 | 135                            | HH135F3          | HH135F4                      | HH135F5 |                |         | HH135F8                         | HH135F9 | HH135F10              | HH135F11 | HH135F12         | HH135F13            |
| Tomatoes               | 136                            | HH136F3          | HH136F4                      | HH136F5 |                |         | HH136F8                         | HH136F9 | HH136F10              | HH136F11 | HH136F12         | HH136F13            |

| Item Description               | Item consumed<br>1=Yes<br>0=No | Unit of Quantity | Consumption out of Purchases |         |                |         | Consumption out of home produce |         | Received in-kind/Free |          | Av. Market Price | Av. Farm gate price |
|--------------------------------|--------------------------------|------------------|------------------------------|---------|----------------|---------|---------------------------------|---------|-----------------------|----------|------------------|---------------------|
|                                |                                |                  | Household                    |         | Away from home |         |                                 |         |                       |          |                  |                     |
|                                |                                |                  | Qty                          | Value   | Qty            | Value   | Qty                             | Value   | Qty                   | Value    |                  |                     |
| 1                              | 2                              | 3                | 4                            | 5       | 6              | 7       | 8                               | 9       | 10                    | 11       | 12               | 13                  |
| Cabbages                       | 137                            | HH137F3          | HH137F4                      | HH137F5 |                |         | HH137F8                         | HH137F9 | HH137F10              | HH137F11 | HH137F12         | HH137F13            |
| Amaranthus(Dodo,O muchicha)    | 138                            | HH138F3          | HH138F4                      | HH138F5 |                |         | HH138F8                         | HH138F9 | HH138F10              | HH138F11 | HH138F12         | HH138F13            |
| Other vegetables               | 139                            | HH139F3          | HH139F4                      | HH139F5 |                |         | HH139F8                         | HH139F9 | HH139F10              | HH139F11 | HH139F12         | HH139F13            |
| Beans (fresh)                  | 140                            | HH140F3          | HH140F4                      | HH140F5 |                |         | HH140F8                         | HH140F9 | HH140F10              | HH140F11 | HH140F12         | HH140F13            |
| Beans (dry)                    | 141                            | HH141F3          | HH141F4                      | HH141F5 |                |         | HH141F8                         | HH141F9 | HH141F10              | HH141F11 | HH141F12         | HH141F13            |
| Ground nuts (in shell)         | 142                            | HH142F3          | HH142F4                      | HH142F5 | HH142F6        | HH142F7 | HH142F8                         | HH142F9 | HH142F10              | HH142F11 | HH142F12         | HH142F13            |
| Ground nuts (shelled)          | 143                            | HH143F3          | HH143F4                      | HH143F5 | HH143F6        | HH143F7 | HH143F8                         | HH143F9 | HH143F10              | HH143F11 | HH143F12         | HH143F13            |
| Ground nuts (pounded)          | 144                            | HH144F3          | HH144F4                      | HH144F5 |                |         | HH144F8                         | HH144F9 | HH144F10              | HH144F11 | HH144F12         | HH144F13            |
| Peas                           | 145                            | HH145F3          | HH145F4                      | HH145F5 |                |         | HH145F8                         | HH145F9 | HH145F10              | HH145F11 | HH145F12         | HH145F13            |
| Simsim                         | 146                            | HH146F3          | HH146F4                      | HH146F5 |                |         | HH146F8                         | HH146F9 | HH146F10              | HH146F11 | HH146F12         | HH146F13            |
| Sugar                          | 147                            | HH147F3          | HH147F4                      | HH147F5 |                |         | HH147F8                         | HH147F9 | HH147F10              | HH147F11 | HH147F12         | HH147F13            |
| Coffee                         | 148                            | HH148F3          | HH148F4                      | HH148F5 | HH148F6        | HH148F7 | HH148F8                         | HH148F9 | HH148F10              | HH148F11 | HH148F12         | HH148F13            |
| Tea                            | 149                            | HH149F3          | HH149F4                      | HH149F5 | HH149F6        | HH149F7 | HH149F8                         | HH149F9 | HH149F10              | HH149F11 | HH149F12         | HH149F13            |
| Salt                           | 100                            | HH100F3          | HH100F4                      | HH100F5 |                |         | HH100F8                         | HH100F9 | HH100F10              | HH100F11 | HH100F12         | HH100F13            |
| Soda*                          | 101                            | HH101F3          | HH101F4                      | HH101F5 | HH101F6        | HH101F7 | HH101F8                         | HH101F9 | HH101F10              | HH101F11 | HH101F12         | HH101F13            |
| Beer*(local/bottled)           | 102                            | HH102F3          | HH102F4                      | HH102F5 | HH102F6        | HH102F7 | HH102F8                         | HH102F9 | HH102F10              | HH102F11 | HH102F12         | HH102F13            |
| Other alcoholic drinks         | 103                            | HH103F3          | HH103F4                      | HH103F5 | HH103F6        | HH103F7 | HH103F8                         | HH103F9 | HH103F10              | HH103F11 | HH103F12         | HH103F13            |
| Other drinks                   | 104                            | HH104F3          | HH104F4                      | HH104F5 | HH104F6        | HH104F7 | HH104F8                         | HH104F9 | HH104F10              | HH104F11 | HH104F12         | HH104F13            |
| Cigarettes                     | 105                            | HH105F3          | HH105F4                      | HH105F5 | HH105F6        | HH105F7 | HH105F8                         | HH105F9 | HH105F10              | HH105F11 | HH105F12         | HH105F13            |
| Other tobacco                  | 106                            | HH106F3          | HH106F4                      | HH106F5 | HH106F6        | HH106F7 | HH106F8                         | HH106F9 | HH106F10              | HH106F11 | HH106F12         | HH106F13            |
| Expenditure in Restaurants on: |                                |                  |                              |         |                |         |                                 |         |                       |          |                  |                     |
| 1. Food                        | 107                            |                  |                              | HH107F5 |                | HH107F7 |                                 | HH107F9 |                       | HH107F11 |                  | HH107F13            |

| Item Description | Item consumed<br>1=Yes<br>0=No | Unit of Quantity | Consumption out of Purchases |         |                |         | Consumption out of home produce |         | Received in-kind/Free |          | Av. Market Price | Av. Farm gate price |
|------------------|--------------------------------|------------------|------------------------------|---------|----------------|---------|---------------------------------|---------|-----------------------|----------|------------------|---------------------|
|                  |                                |                  | Household                    |         | Away from home |         |                                 |         |                       |          |                  |                     |
|                  |                                |                  | Qty                          | Value   | Qty            | Value   | Qty                             | Value   | Qty                   | Value    |                  |                     |
| 1                | 2                              | 3                | 4                            | 5       | 6              | 7       | 8                               | 9       | 10                    | 11       | 12               | 13                  |
| 2. Soda          | 108                            | HH108F3          | HH108F4                      | HH108F5 | HH108F6        | HH108F7 | HH108F8                         | HH108F9 | HH108F10              | HH108F11 | HH108F12         | HH108F13            |
| 3. Beer          | 109                            | HH109F3          | HH109F4                      | HH109F5 | HH109F6        | HH109F7 | HH109F8                         | HH109F9 | HH109F10              | HH109F11 | HH109F12         | HH109F13            |
| Other juice      | 160                            |                  |                              | HH160F5 |                | HH160F7 |                                 | HH160F9 |                       | HH160F11 |                  | HH160F13            |
| Other foods      | 161                            |                  |                              | HH161F5 |                | HH161F7 |                                 | HH161F9 |                       | HH161F11 |                  | HH161F13            |

\* Sodas and Beers to be recorded here are those that are not taken with food in restaurants.

## SECTION 20: Household food insecurity access scale

I am going to ask you questions about your household's food supply over the past four weeks. Food supply includes staples, sauces, and any other foods in your diet and the diets of all members of your household.

### 20.1. Household Food Insecurity Access Scale

| No.     | Question (Response: 1=Yes; 0=No)   | No.     | Frequency [1 = Rarely (once or twice in the past four weeks)<br>2 = Sometimes (3 to 10 times in the past four weeks)<br>3 = Often (more than 10 times in the past four weeks)] |
|---------|--|---------|--|
| 20.1.1  | In the past four weeks, did you <u>worry</u> that your household would not have enough food?   | 20.1.2  | If yes, how often did this happen? .....   |
| 20.1.3  | In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources? .....                                      | 20.1.4  | If yes, how often did this happen? .....   |
| 20.1.5  | In the past four weeks, did you or any household member have to eat a limited variety of foods due to lack of resources? .....   | 20.1.6  | If yes, how often did this happen? .....   |
| 20.1.7  | In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of lack of resources to obtain other types of food? ..... | 20.1.8  | If yes, how often did this happen? .....   |
| 20.1.9  | In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food? .....                                 | 20.1.10 | If yes, how often did this happen? .....   |
| 20.1.11 | In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?  | 20.1.12 | If yes, how often did this happen? .....   |
| 20.1.13 | In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food? .....  | 20.1.14 | If yes, how often did this happen? .....   |
| 20.1.15 | In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food? .....   | 20.1.16 | If yes, how often did this happen? .....   |
| 20.1.17 | In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food? .....                                    | 20.1.18 | If yes, how often did this happen? .....   |

### 20.2. How do you cope with situations of lack/scarcity of food? (Multiple choice)

1-Do nothing / stay hungry; 2-Rely on food aid; 3-Borrow from friends / relatives; 4-Work for food / money; 5-Reduce on no. meals; 6-Reduce the quantity of food prepared; 991-other, specify

### 20.3. What is the average number of meals per day in your household in the last 4 weeks?

## SECTION 21: Infrastructure and institutional support services

### Institutional Interventions or services in place

| Institutions/service         | Is this service/intervention available in your area? 1=Yes<br>0=No | Do you or any member of the household have access to this service<br>1=Yes<br>0=No | Distance from your home to the nearest point of access to this service (in KM) | Did any of the household members participate or access services from this institution in the last 12 months?<br><br>1=Yes; 0=No | Who in the household directly participated or accessed this service?<br>(multiple)<br><br>1=husband; 2=wife;<br>3=mother; 4=father;<br>5=grandfather;<br>6=grandmother; 7= male child; 8=female child; 991=other, specify | No. of times the household has been in contact with the institution that provides this service in the last one year? | Who is responsible for facilitating access to this service/intervention?<br><br>1=The community;<br><br>2. NAADS; 3=NGOs*;<br><br>4=Private sector;<br>5=FAO; 6=NARO/ARI<br><br>7=Others (specify) | If NGO, please specify |
|------------------------------|--|--|--|---|---|--|--|------------------------|
| Extension Services           |  |  |  |   |   |  |  |                        |
| Development Agencies (NGOs)  |  |  |  |   |   |  |  |                        |
| Agricultural product markets |  |  |  |   |   |  |  |                        |
| Agricultural input markets   |  |  |  |   |   |  |  |                        |
| Planting material            |  |  |  |   |   |  |  |                        |
| Community health services    |  |  |  |   |   |  |  |                        |
| Human nutrition services     |  |  |  |   |   |  |  |                        |
| All-weather road (tarmac)    |  |  |  |   |   |  |  |                        |
| Credit facilities/Banks      |  |  |  |   |   |  |  |                        |

**SECTION 22: Farmer attitude assessment**

Give the degree to which you agree with the following statements

**(1=Strongly disagree; 2=somewhat disagree; 3=neither disagree nor agree; 4=somewhat agree; 5=strongly agree)**

- a. I would prefer if my children do not end up working as farmers
- b. There is no hope for poor farmers like us to improve
- c. If I had a choice I would not be a full time farmer
- d. There is no better investment than farming
- e. God meant me to be a farmer/it is my destiny to be a farmer
- f. I am proud to be a farmer
- g. Any farming method that saves me time is worth paying for

***Thank you very much for your cooperation***

## Appendix 2: Follow-up Survey Questionnaire

01. Date of interview: Day: \_\_\_\_Month: \_\_\_\_Year: \_\_\_\_
02. Enumerator Name: \_\_\_\_\_ Supervisor Name: \_\_\_\_\_
03. Country: \_\_\_\_\_ District: \_\_\_\_\_ Sub-County / Division: \_\_\_\_\_  
Parish / Ward: \_\_\_\_\_ Village: \_\_\_\_\_
04. Geographical location: Latitude: \_\_\_\_\_ ° \_\_\_\_\_ M \_\_\_\_\_ S  
Longitude: \_\_\_\_\_ ° \_\_\_\_\_ M \_\_\_\_\_ S  
Elevation [metres]: \_\_\_\_\_
05. Telephone contact of respondent: \_\_\_\_\_
06. Respondent's Name: \_\_\_\_\_
07. Respondent's Age: \_\_\_\_\_ years
08. Short description of location eg: next to church: \_\_\_\_\_
09. Language used in interview: \_\_\_\_\_
10. Time: \_\_\_\_\_ (Start) \_\_\_\_\_ (End)

### SECTION 1: General household information

- 1a. Household Head (HHH) Name: \_\_\_\_\_
- 1b. Gender of HHH: \_\_\_\_\_ [1= Male, 2= Female]
- 1c. Age of HHH(years): \_\_\_\_\_  
1c.(i).HHH Age range if the respondent cannot specify the HHH age: \_\_\_\_\_
- 1d. Marital status of HHH: \_\_\_\_\_ [1= Single, 2= Married, 3= Widowed/divorced/separated]
- 1e. Main occupation of HHH: \_\_\_\_\_ (See Occupation Codes)
- 1f. Main Respondent: \_\_\_\_\_ [1= HH head, 2= Spouse, 3= Son/daughter, 4 = other specify]
- 1g. Gender of Respondent: \_\_\_\_\_ [1= Male, 2= Female]

**Occupation codes:** 1= Farming, 2= Trading, 3= Salary employment, 4= other off-farm employment, 999= None / N/A

**General codes:** 991=Other      997=No idea      999=None/not applicable

## SECTION 2: Farm household composition and off-farm activities in last 12 months (June 2021 to May 2022)

| HH Member | Name | Position in HH (Code) | Age (yrs) | Gender (Code) | Formal Education. (yrs) | Farming experience (yrs) | Time on-farm (1=Full time 0=Part time) | Off-farm work (Code) | Farmers' group membership (1=yes; 0=No) | Years in farmer's group | Savings & credit group membership (1=Yes; 0=No) | Years in savings & credit group | Self-help group membership (1=Yes; 0=No) | Years in self-help group | Remarks |
|-----------|------|-----------------------|-----------|---------------|-------------------------|--------------------------|--|----------------------|---|-------------------------|---|---------------------------------|--|--------------------------|---------|
| HH1       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH2       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH3       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH4       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH5       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH6       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH7       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH8       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH9       |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH10      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH11      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH12      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH13      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH14      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |
| HH15      |      |                       |           |               |                         |                          |  |                      |   |                         |   |                                 |  |                          |         |

**Position in HH:** 1- head, 2- husband/wife, 3- son/ daughter, 4- son/daughter in law, 5-father/mother, 6-grandchild, 7-sibling, 8-permanently employed worker, 9- sister/brother-in-law, 991-other, specify;

**Gender:** 1-male, 2-female;

**Off-farm work:** 1-agricultural (off-farm), 2-non-agricultural labour (off-farm), 3-regular employment, government, 4-regular employment, private formal, 5-regular employment, informal, 6-self-employed (no employees), 7-business (with employees), 8-student, 991-other (specify)

### SECTION 3: Housing, Water and Sanitation Conditions

#### 3a. Housing/Shelter conditions

|   |   |   |  |  |
|---|---|---|--|--|
| What is the <b>major</b> construction material of the roof?<br>1=Iron sheets<br>2=Tiles<br>3=Asbestos<br>4=Concrete<br>5=Tin<br>6=Thatch<br>991=Other (specify)<br>INTERVIEWER PLEASE USE OBSERVATION | What is the <b>major</b> construction material of the external wall?<br>1=Concrete/stones<br>2=Cement blocks<br>3=Burnt/stabilized bricks<br>4=Unburnt bricks with cement<br>5= Unburnt bricks with mad<br>6=Wood<br>7=Mad and pole<br>8=Tin/iron sheets<br>991=Other (specify)<br>INTERVIEWER PLEASE USE OBSERVATION | What is the <b>major</b> construction material of the floor?<br>1=Concrete<br>2=Bricks<br>3=Stone<br>4=Cement screed<br>5=Rammed earth<br>6=Wood<br>7=Tiles<br>INTERVIEWER PLEASE USE OBSERVATION | Does the house have GRID electricity?<br>1=Yes<br>2=No | Does the house have solar energy?<br>1=Yes<br>2=No |
| 3a.1  | 3a.2  | 3a.3  | 3a.4   | 3a.5   |
|   |   |   |  |  |
|   |   |   |  |  |
|   |   |   |  |  |

#### 3b. Water and Sanitation Conditions

|  |   |   |  |   |  |  |   |   |
|--|---|---|--|---|--|--|---|---|
| What is the <b>main</b> source of water for your household?<br>1=Piped water into dwelling<br>2= Piped water to the yard<br>3=Public taps<br>4=Borehole in yard/plot<br>5=Public borehole<br>6=Protected well/spring<br>7=Unprotected well/spring<br>8=River/stream/lake<br>9=Vendor<br>10=Tanker truck<br>11=Gravity flow scheme<br>12=Rainwater<br>991=Other (specify) | How long does it take to walk from your dwelling to the <b>main</b> water source and back in minutes? | Is the water used by the household paid for?<br>1=Yes<br>2=No | What is the purpose of the payment?<br>1=User fees/tariffs<br>2=Maintenance costs<br>3=Transportation costs<br>991=Other (specify) | How much money, on average, does the household pay per month for the water? (Shillings) | What type of toilet is <b>mainly</b> used by your household?<br>1=Flush/pour flash<br>2=Ventilated Improved pit latrine<br>3=Ordinary pit latrine<br>4=Composting toilet<br>5=Bucket<br>6=No facility/ bush/ field/ polythene<br>991=Other (specify) | Does the household share this toilet facility with other households?<br>1=Yes<br>2=No<br>3=N/A | With how many other households does this household share this toilet? | Do you have a hand wash facility at the toilet or on the premises?<br>1=No<br>2=Yes with water only<br>3= Yes with water and soap<br>INTERVIEWER PLEASE USE OBSERVATION |
| 3b.1   | 3b.2  | 3b.3  | 3b.4   | 3b.5  | 3b.6   | 3b.7   | 3b.8  | 3b.9  |
|  |   |   |  |   |  |  |   |   |
|  |   |   |  |   |  |  |   |   |
|  |   |   |  |   |  |  |   |   |

## SECTION 4: Land ownership and crop production

- 4a. How much land do you own in total as a household? \_\_\_\_\_ acres
- 4b. In the last 12 months, did you borrow/rent/hire land? 1=Yes, 0=No
- 4b.1 If yes, how many acres? \_\_\_\_\_ acres
- 4b.2 If yes, which crops are cultivated on the borrowed/rented/hired land? \_\_\_\_\_ (1= Bananas, 2= Rice, 3=Beans, 4= Maize, 5= cassava, 6= others specify)
- 4c. How much of the land is cultivated? \_\_\_\_\_ acres
- 4d. Of the cultivated land, how much in total is used for banana production? \_\_\_\_\_ acres
- 4e. Are the bananas intercropped? 1=Yes; 0=No
- 4e.1 If yes, with which crop(s)? (1. Cassava, 2. Beans, 3. Coffee, 4. Rice, 5. Maize, 6. Eggplant, 7. Others (specify here) \_\_\_\_\_
- 4e.2 What proportion (percentage) is covered by intercrops? \_\_\_\_\_
- 4f.1 On how many plots do you cultivate? \_\_\_\_\_
- 4f.2 Of these plots, on how many do you grow banana? \_\_\_\_\_
- 4g. For each of the plots you cultivate, please provide the production details in the following table: **(Crop Production)** *Instructions to enumerator: please ask about all crops produced.*

| Season<br>(code) | Plot ID<br>(from<br>sec. 3) | Crop<br>(code) | Area<br>(acres) | Unit used<br>(e.g. sack,<br>tin, basin,<br>bunch,<br>basket, etc) | Weight of<br>each unit in<br>kg | Production<br>(total units) | HH<br>food<br>consumption<br>(units) | Payment<br>in kind<br>(units) | Livestock<br>feed<br>(units) | Kept as<br>seed<br>(units) | Other<br>deductio<br>ns<br>(donatio<br>ns,<br>storage<br>etc)<br>(units) | Product sales           |                        |                          |   |  |
|------------------|-----------------------------|----------------|-----------------|---|---------------------------------|-----------------------------|--------------------------------------|-------------------------------|------------------------------|----------------------------|--|-------------------------|------------------------|--------------------------|---|--|
|                  |                             |                |                 |   |                                 |                             |                                      |                               |                              |                            |  | Quantit<br>y<br>(units) | Unit<br>price<br>(Shs) | Main<br>buyer<br>(codes) | Who makes<br>the decision<br>to sell?<br>1=husband<br>2=wife<br>3=1&2 (both)<br>4=boy child<br>5=girl child<br>6=family<br>7=others | Who decides<br>use of<br>income?<br>1=husband<br>2=wife<br>3=1&2 (both)<br>4=boy child<br>5=girl child<br>6=family<br>7=others |
|                  |                             |                |                 |   |                                 |                             |                                      |                               |                              |                            |  |                         |                        |                          |   |  |
|                  |                             |                |                 |   |                                 |                             |                                      |                               |                              |                            |  |                         |                        |                          |   |  |
|                  |                             |                |                 |   |                                 |                             |                                      |                               |                              |                            |  |                         |                        |                          |   |  |
|                  |                             |                |                 |   |                                 |                             |                                      |                               |                              |                            |  |                         |                        |                          |   |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**Season:** 1-Main (long rain) season, 2-Short rain season;

**Crop code:**

**Bananas:** 11=Bananas; **Cereals:** 21=Maize; 22=Sorghum; 23=Millet; 24=Rice; 25=Other (specify); **Roots and tubers:** 31=Cassava; 32=Irish potato; 33=Sweet potato; 34=Yam; 35=Other (specify); **Legumes:** 41=Beans; 42=Soybean; 43=Cowpea; 44=Groundnuts; 45= Other (specify); **Cash crops:** 51=Coffee; 52=Tea; 53=Cotton; 54=Sugarcane; 55=Sunflower; 56=Simsim; 57= Other (specify); **Vegetables:** 61=Tomato; 62=Pepper; 63=Pumpkin; 64=Carrot; 65=Onion; 66=Okra; 67=Cauliflower; 68=Cabbage; 69=Amaranth leaves (dodo); 610= Other (specify); **Fruits:** 71=Mango; 72=Pawpaw; 73=Avocado; 74=Jackfruit; 75=Passion fruits; 76=Watermelon; 77=Pineapple; 78=Oranges; 79=Apples; 710= Other (specify); **General:** 81=Pastures; 82=Fallow; 810=Other (specify)

**Main Buyer:** 1-Local market, 2-Neighbour, 3-Retailer, 4-Wholesaler, 5-Broker, 6-Processor, 7-Co-operative, 8-Trader/Middle-man, 991-Other (specify), 999=None/NA

## SECTION 5: Activity calendar and labour allocation in banana husbandry only in the last 12 months (June 2021 to May 2022)

A). Please tell me about the labour you used on your **BANANA PLOTS** in the period.

**DEFINITION:** ONE PERSON-DAY IS THE NUMBER OF PERSON MULTIPLIED BY THE NUMBER OF DAYS THEY WORK. IF ONE PERSON WORKS 3 DAYS AND TWO OTHER WORK 5 DAYS EACH, THE NUMBER OF PERSON-DAY IS EQUAL TO 13 (= 3 DAYS + 5 DAYS + 5 DAYS)].

| Activity                               | Done in this period?<br>(1=Yes; 0=No) | Family labour          |   |             |            | Hired labour           |  |             |            |       |       |                                    |
|--|---------------------------------------|------------------------|---|-------------|------------|------------------------|--|-------------|------------|-------|-------|------------------------------------|
|  |                                       | No of persons involved |   | Person days | Work hours | No of persons involved |  | Person days | Work hours | Wages | Units | Value for hired labour (UG/TZ Shs) |
| Land preparation                       |                                       | Male                   |   |             |            | Male                   |  |             |            |       |       |                                    |
|  |                                       | Female                 |   |             |            | Female                 |  |             |            |       |       |                                    |
| Digging holes                          |                                       | Male                   |   |             |            | Male                   |  |             |            |       |       |                                    |
|  |                                       | Female                 |   |             |            | Female                 |  |             |            |       |       |                                    |
| Transportation of plantlets            |                                       | Male                   |   |             |            | Male                   |  |             |            |       |       |                                    |
|  |                                       | Female                 |   |             |            | Female                 |  |             |            |       |       |                                    |
| Planting                               |                                       | Male                   |   |             |            | Male                   |  |             |            |       |       |                                    |
|  |                                       | Female                 |   |             |            | Female                 |  |             |            |       |       |                                    |
| Pruning and/or thinning / de-suckering |                                       | Male                   |   |             |            | Male                   |  |             |            |       |       |                                    |
|  |                                       | Female                 |   |             |            | Female                 |  |             |            |       |       |                                    |
| Weeding (Hand, Slash, Spray)           | 1                                     | Male                   | 1 | 72          | 6          | Male                   |  |             |            |       |       |                                    |
|  |                                       | Female                 | 2 | 144         | 4          | Female                 |  |             |            |       |       |                                    |
| Irrigating                             |                                       | Male                   |   |             |            | Male                   |  |             |            |       |       |                                    |

|                                |   |        |   |     |       |        |  |  |  |  |  |  |  |
|--------------------------------|---|--------|---|-----|-------|--------|--|--|--|--|--|--|--|
|                                |   | Female |   |     |       | Female |  |  |  |  |  |  |  |
| Applying manure or fertilisers |   | Male   |   |     |       | Male   |  |  |  |  |  |  |  |
|                                |   | Female |   |     |       | Female |  |  |  |  |  |  |  |
| Applying mulch                 |   | Male   |   |     |       | Male   |  |  |  |  |  |  |  |
|                                |   | Female |   |     |       | Female |  |  |  |  |  |  |  |
| Digging trenches/basins        |   | Male   |   |     |       | Male   |  |  |  |  |  |  |  |
|                                |   | Female |   |     |       | Female |  |  |  |  |  |  |  |
| Harvesting                     | 1 | Male   | 1 | 96  | 1     | Male   |  |  |  |  |  |  |  |
|                                |   | Female | 1 | 365 | 0.081 | Female |  |  |  |  |  |  |  |
| Transporting produce           |   | Male   |   |     |       | Male   |  |  |  |  |  |  |  |
|                                |   | Female |   |     |       | Female |  |  |  |  |  |  |  |
| Record keeping                 |   | Male   |   |     |       | Male   |  |  |  |  |  |  |  |
|                                |   | Female |   |     |       | Female |  |  |  |  |  |  |  |
| Others (specify)...            |   | Male   |   |     |       | Male   |  |  |  |  |  |  |  |
|                                |   | Female |   |     |       | Female |  |  |  |  |  |  |  |

## SECTION 6: Integrated soil fertility and pest management practices implemented in banana cropping systems

6. (i) Do you implement any pest control practices in your banana plots? 1=Yes; 0=No (If yes, proceed to fill in the table below)

| Plot No. (from sec. 3)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| (ii). List <u>the pest control practices</u> used on the plot (use PCP codes)                          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Year establishing the PC practice on this plot  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Source of information on the practice (see codes)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Perceived effectiveness of practice on increasing banana growth and yield in your field (see codes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Are there any PCP that you are aware of but not using in your field? [1= Yes, 0= No]                |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. If yes, list them (see PCP codes)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Reasons for not using the practice (see codes)  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**PCP Codes:** 1= Traps, 2= Uprooting, 3= Use of inorganic pesticides, 4=Use of organic/local pesticides, 5=Corm removal, 6 = Chopping Pseudo-stems, 7= Burning, 999=None/N/A, 991= Other specify \_\_\_\_\_

**#(ii)b Codes:** 1= Gov't Ext. agent, 2= NGO ext. agent, 3= Fellow farmer, 4=NARO/TARI, 5=Demo plot, 6=Radio, 7=Television, 8=Drama 999=None/N/A, 991= Other specify \_\_\_\_\_

**#(ii)c Codes:** 1=Not effective, 2=slightly effective, 3=moderately effective, 4= effective, 5=very effective

#(ii)f Codes: 1 = Too expensive, 2= Too labour intensive, 3= Not beneficial, 4= Not interested, 999=None/N/A, 991= Other specify\_\_\_\_\_

6. (iii) Do you implement any soil fertility practices in your banana plots? 1=Yes; 0=No (If yes, proceed to fill in the table below)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| Plot ID (PID) (from sec. 3)  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| (iv). List <b>the soil fertility practices</b> used on the plot (use SFP codes)                              |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Year establishing the SF practice on this plot  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Source of information on the practice (see (ii)b codes)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Perceived effectiveness of practice on increasing banana growth and yield in your field (see (ii)c codes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Are there any SFP that you are aware of but not using in your field? [1= Yes, 0= No]                      |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. If yes, list them (see SFP codes)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. Reasons for not using the practice (see (ii)f codes)  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**SFP Codes:** 1= Intercropping legumes, 2=Animal manure application, 3=Compost application, 4=Use of crop residues, 5= Inorganic fertilizer application, 7= Fallowing, 999=None/N/A, 991= Other specify\_\_\_\_\_

6. (v) Do you implement any soil and water conservation practices on your banana plots? 1=Yes; 0=No(If yes, proceed to fill in the table below)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| Plot ID (PID) (from sec. 3)  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| (vi). List <b>the SWC practices</b> on the plot (use SWC codes)  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| a. Year establishing the SWC practice on this plot   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| b. Source of information on this SWC practice (see (ii)b codes)  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| c. Proportion of plot conserved or protected by the SWC practice (%)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| d. Perceived effectiveness of practice on increasing banana growth and yield in your field (see (ii)c codes) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| e. Are there any SWC practices that you are aware of but not using in your field? [1= Yes, 0= No]            |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| f. If yes, list them (see SWC codes)   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| g. Reasons for not using the practice (see (ii)f codes)  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**SWC Codes:** 1 = Mulching, 2 = Trenches/Diversion channels, 3 = Basins, 4 = Contour ploughing, 5 = Grass/and soil bunds, 6 = Grass strips, 7 = Terracing, 8 = Trash lines, 9= Minimum tillage, 10 = Irrigation, 11 = Fallowing, 999=None/N/A, 991= Other specify\_\_\_\_\_

## SECTION 7: Sources of information on banana management practices since 2017.

7a. Since 2017, have you received any information regarding banana practices?

1=Yes, 0=No. *Instructions to enumerator: please probe for any involvement of the respondent or member of the household in any banana agronomy activity e.g. farmer field days, demo establishment, farmer meetings, project launch, farmer exchange visits, scaling agent training, radio campaigns, Drama screening etc.). If no, skip to section 7.*

7b. If yes, please tell us the different sources of information and rate their effectiveness in banana management and production using a scale of 1 (very ineffective) to 5 (very effective):

| Source of information                | Response   | Effectiveness        |                 |             |               |                    |
|--------------------------------------|--|----------------------|-----------------|-------------|---------------|--------------------|
|                                      |  | Response             |                 |             |               |                    |
|                                      |  | Very ineffective (1) | Ineffective (2) | Average (3) | Effective (4) | Very effective (5) |
| Radio                                | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Farmer meetings                      | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Demo plot                            | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Extension agents at all levels       | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Site coordinators                    | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Farmer field days                    | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Posters/flyers/leaflets              | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Farmers' or social/ religious groups | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Local councils                       | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Television                           | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| NARO/TARI                            | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| NGOs (national or international)     | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Mobile vans                          | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Drama videos                         | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Family                               | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Neighbors                            | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Friends                              | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Exchange visit                       | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |
| Others (please specify)              | <input type="checkbox"/> 1=Yes <input type="checkbox"/> 0=No |                      |                 |             |               |                    |

- 7c. (i) What new banana management information has been learnt in that period? \_\_\_\_\_
- 7d. (ii) How many people have you shared information related to banana management with? \_\_\_\_\_
- 7d. (iii) Of those how many people are implementing the recommended banana management practices? \_\_\_\_\_
- 7d. (iv) Which banana management practice(s) are they implementing? \_\_\_\_\_ (See management codes below)

**Banana management practices codes:** (1=Mulching; 2= Digging trenches; 3= Digging basins; 4= Weevil trapping; 5=Fertilizer application; Manure application; 7= Corm removal; 8= Male bud removal; 9=De-suckering; 10= Pruning; 11=Chopping pseudo stems; 12= Other, specify).

## Section 8: Rainfall patterns

*Now I would like to ask you about rainfall supply during the past 12 months in comparison to the seasons in 2017 at the onset of project intervention.*

1. Compared to 2017, have you observed any changes in the rainfall patterns? \_\_\_\_\_ (0=No; 1=Yes; 2= I don't know)
2. In the previous two seasons, what has the rainfall intensity been like, compared to that in 2017? \_\_\_\_\_ (1=Heavier rains, 2=The same/no difference, 3= Lighter rains, 4=I don't know).
3. How would you describe the rainfall pattern in the previous 2 seasons compared to that in 2017? \_\_\_\_\_ (1=More reliable; 2=Less reliable; 3=Unreliable; 4= I don't know).
4. What has been the rainfall trend in the previous 2 seasons? (1=Adequate; 2=Excess leading to floods; 3=Inadequate; 4=I don't know).

## SECTION 9: Livestock in the last 12 months (June 2021 to May 2022)

### 9.1. Do you have livestock? (1 = Yes; 0 = No)

### 9.2. If yes, list them..... (see livestock codes)

**Livestock Codes:** 1-Cattle, 2-Bufferaloe, 3-Goat, 4-Sheep, 5-Pig, 6-Chicken, 7-Quail, 8-Duck, 9-Goose, 10-Turkey, 11-Guinea fowl, 12-Pigeon, 13-Rabbit, 14-Guinea pig, 15-Donkey, 16-Mule, 17-Horse, 18-Bee hive, 991-Other (specify)

### 9.3. Non-ruminant livestock species in the last 12 months:

| Livestock (code) | Gender ownership (code) | Total number of animals | Adult females | Adult males | Young | Remarks |
|------------------|-------------------------|-------------------------|---------------|-------------|-------|---------|
|                  |                         |                         |               |             |       |         |
|                  |                         |                         |               |             |       |         |
|                  |                         |                         |               |             |       |         |
|                  |                         |                         |               |             |       |         |

**Livestock:** 1-Chicken, 2-Quails, 3-Ducks, 4-Turkeys, 5-Guinea fowl, 6-Guinea pigs, 7-Geese, 8-Pigeon, 9-Rabbits, 10-Donkeys, 11-Horses, 12-Bee hives, 991-Other;

**Gender Codes:** 1= Husband, 2= Wife, 3= Joint (husband & wife), 4- son/ daughter, 5- son/daughter in law, 6- father/mother, 7-grandchild, 8-sibling, 9-permanently employed worker, 10- sister/brother-in-law, 11-Single male, 12-Single female, 991-other, specify;

**SECTION 10: Livestock products in the last 12 months (June 2021 to May 2022):**

|                |                  |                     | Production            | Sales                 |                  |                    |                               |                   | HH human consumption  | Other (e.g. gift, donation stored etc.) | Remarks |
|----------------|------------------|---------------------|-----------------------|-----------------------|------------------|--------------------|-------------------------------|-------------------|-----------------------|---|---------|
| Product (code) | Livestock (code) | Data period (codes) | quantity [prod. code] | quantity [prod. code] | Unit cost (Shs.) | total value [Shs.] | income control, gender (code) | main buyer (code) | quantity [prod. code] | quantity [prod. code]                   |         |
|                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |
|                |                  |                     |                       |                       |                  |                    |                               |                   |                       |   |         |

**Data Period Codes:** 1=Daily; 2=Whole season

**Product / Service:** 1-Milk [ltr], 2-Curd/yoghurt [kg], 3-Butter [kg], 4-Ghee [kg], 5-Cheese [kg], 6-Khoya/Chena [kg], 7-Meat [kg], 8-Eggs [no.], 9-Whole animal (no.), 10-Hair [kg], 11-Hides/skin [no.], 12-Honey [kg], 13-Beeswax [kg], 14-Wool [kg], 15-Manure [kg]; 16-Male service (bull, goat, pig, etc); 999-None/NA, 991-Other, specify;

**Livestock:** 1-Cattle, 2-Bufferloe, 3-Goat, 4-Sheep, 5-Pig, 6-Chicken, 7-Quail, 8-Duck, 9-Goose, 10-Turkey, 11-Guinea fowl, 12-Pigeon, 13-Rabbit, 14-Guinea pig, 15-Donkey, 16-Mule, 17-Horse, 18-Bee hive, 991-Other (specify)

**Gender Codes:** 1= Husband, 2= Wife, 3= Joint (husband & wife), 4- son/ daughter, 5- son/daughter in law, 6-father/mother, 7-grandchild, 8-sibling, 9-permanently employed worker, 10- sister/brother-in-law, 11-Single male, 12-Single female, 991-other, specify

**Main Buyer:** 1-Local market, 2-Neighbour, 3-Retailer, 4-Wholesaler, 5-Broker, 6-Processor, 7-Co-operative, 8-Trader/Middleman, 999-None/NA, 991-Other (specify)

## SECTION 11: Farm assets

| Name of asset                           | Do you own<br>1 = yes<br>0 = no | Total number<br>owned (No.) | Access/Use 1.<br>Woman2. Man3.<br>Both4. Other | Ownership<br>1. Woman2. Man3.<br>Both4. Other | Control of Usage<br>1. Woman2. Man3.<br>Both4. Other | Approximate today's<br>value<br>(UG. Shs) | Notes |
|---|---------------------------------|-----------------------------|--|---|--|---|-------|
| <b>Transport</b>                        |                                 |                             |  |   |  |   |       |
| Car/Truck                               |                                 |                             |  |   |  |   |       |
| Motorcycle                              |                                 |                             |  |   |  |   |       |
| Bicycle                                 |                                 |                             |  |   |  |   |       |
| Cart (animal drawn)                     |                                 |                             |  |   |  |   |       |
| <b>Farm</b>                             |                                 |                             |  |   |  |   |       |
| Hoes                                    |                                 |                             |  |   |  |   |       |
| Spades/shovel                           |                                 |                             |  |   |  |   |       |
| Ploughs                                 |                                 |                             |  |   |  |   |       |
| Sprayer pump/Knapsack                   |                                 |                             |  |   |  |   |       |
| Water pump                              |                                 |                             |  |   |  |   |       |
| Wheelbarrow                             |                                 |                             |  |   |  |   |       |
| Water tank                              |                                 |                             |  |   |  |   |       |
| Tractor                                 |                                 |                             |  |   |  |   |       |
| Stores / silos                          |                                 |                             |  |   |  |   |       |
| Zero grazing units                      |                                 |                             |  |   |  |   |       |
| Incubator                               |                                 |                             |  |   |  |   |       |
| Mills (maize,,rice,,coffee)             |                                 |                             |  |   |  |   |       |
| Chaff cutter                            |                                 |                             |  |   |  |   |       |
| Sickle                                  |                                 |                             |  |   |  |   |       |
| Panga                                   |                                 |                             |  |   |  |   |       |
| Pruning knife                           |                                 |                             |  |   |  |   |       |
| Axe                                     |                                 |                             |  |   |  |   |       |
| Rake                                    |                                 |                             |  |   |  |   |       |
| Forked hoe                              |                                 |                             |  |   |  |   |       |
| Slasher                                 |                                 |                             |  |   |  |   |       |
| Spear                                   |                                 |                             |  |   |  |   |       |
| <b>Buildings (leave out Home house)</b> |                                 |                             |  |   |  |   |       |
|   |                                 |                             |  |   |  |   |       |
|   |                                 |                             |  |   |  |   |       |
| <b>Communication</b>                    |                                 |                             |  |   |  |   |       |
| Phone                                   |                                 |                             |  |   |  |   |       |
| Radio                                   |                                 |                             |  |   |  |   |       |
| Television                              |                                 |                             |  |   |  |   |       |
| <b>Others</b>                           |                                 |                             |  |   |  |   |       |
|   |                                 |                             |  |   |  |   |       |
|   |                                 |                             |  |   |  |   |       |

11b. Did the wife bring any assets into the marriage? (1=Yes, 2=No).

**SECTION 12: Household income (farm and off-farm income in the last 12 months (June 2021 to May 2022))**[illegible]

**Income source:** 1- agricultural labour (off-farm), 2- non-agricultural labour (off-farm), 3-regular employment, government, 4-regular employment, private formal, 5-regular employment, informal, 6-self-employed (no employees), 7-business (with employees), 8-remittances, 9-income from land, 10-interest, 12-pension, 13-rental income, 14-livestock products, 999-None/NA, 991-other, specify;

**Gender Codes:** 1= Husband, 2= Wife, 3= Joint (husband & wife), 4- son/ daughter, 5- son/daughter in law, 6- father/mother, 7-grandchild, 8-sibling, 9-permanently employed worker, 10- sister/brother-in-law, 11-Single male, 12-Single female, 991-other, specify

**SECTION 13: Household expenses in the last 12 months (June 2021 to May 2022)***(Note: If the respondent cannot breakdown the expenditure, capture the figure in the "total cost" column)*

| Expense item   | Frequency (codes) | Quantity | Units | Unit cost (Shs.) | Total Cost (Shs) | Notes |
|--|-------------------|----------|-------|------------------|------------------|-------|
| <b>Housing</b>   |                   |          |       |                  |                  |       |
| 11-House rent  |                   |          |       |                  |                  |       |
| 12-Water   |                   |          |       |                  |                  |       |
| 13-Hh fuel (Firewood, Charcoal, Kerosene, LPG, Biogas) |                   |          |       |                  |                  |       |
| 14-Electricity   |                   |          |       |                  |                  |       |
| 19-Other housing expenses                              |                   |          |       |                  |                  |       |
| <b>Personal</b>  |                   |          |       |                  |                  |       |
| 21-Soap & other toiletries                             |                   |          |       |                  |                  |       |
| 22-Batteries (dry)                                     |                   |          |       |                  |                  |       |
| 23-Newspapers  |                   |          |       |                  |                  |       |
| 29-Other personal                                      |                   |          |       |                  |                  |       |
| <b>Transport &amp; Communication</b>                   |                   |          |       |                  |                  |       |
| 31-Transport fuel (petrol, diesel)                     |                   |          |       |                  |                  |       |
| 32-Public transport charges                            |                   |          |       |                  |                  |       |
| 33-Post (Stamps, envelopes)                            |                   |          |       |                  |                  |       |
| 34-Phone   |                   |          |       |                  |                  |       |
| 35-Airtime   |                   |          |       |                  |                  |       |
| 39-Other   |                   |          |       |                  |                  |       |
| <b>Health</b>  |                   |          |       |                  |                  |       |
| 41-Doctor consultation                                 |                   |          |       |                  |                  |       |
| 42-Medicine  |                   |          |       |                  |                  |       |
| 43-Hospital/clinic                                     |                   |          |       |                  |                  |       |
| 44-Traditional health service                          |                   |          |       |                  |                  |       |
| 49-Other health expenses                               |                   |          |       |                  |                  |       |
| <b>Other categories</b>                                |                   |          |       |                  |                  |       |

| Expense item  | Frequency (codes) | Quantity | Units | Unit cost (Shs.) | Total Cost (Shs) | Notes |
|---|-------------------|----------|-------|------------------|------------------|-------|
| 51-Other services (sports, theatre, laundry, domestic help, barber etc.)        |                   |          |       |                  |                  |       |
| 61-Clothing & footwear (exclude uniform)  |                   |          |       |                  |                  |       |
| 71-Furniture  |                   |          |       |                  |                  |       |
| 81-Hh appliances  |                   |          |       |                  |                  |       |
| 91-Glass & tableware  |                   |          |       |                  |                  |       |
| 101-Education (all e.g. fees, uniform, etc.)                                    |                   |          |       |                  |                  |       |
| 111-Social and other services (functions, ceremonies, funerals, insurance etc.) |                   |          |       |                  |                  |       |
| <b>Non-consumptive expenses</b>   |                   |          |       |                  |                  |       |
| 121-Remittance payments   |                   |          |       |                  |                  |       |
| 122-Interest payments   |                   |          |       |                  |                  |       |
| 123-Pension & social security payments  |                   |          |       |                  |                  |       |
| 124-Tax payments (income, property, local service, ground rent)                 |                   |          |       |                  |                  |       |
| 129-Other non-consumptive expenses  |                   |          |       |                  |                  |       |
| <b>Salaries</b>   |                   |          |       |                  |                  |       |
| 131-Salaries paid to permanently employed workers                               |                   |          |       |                  |                  |       |
| <b>Other livestock expenses (exc. Ruminants &amp; pigs)</b>                     |                   |          |       |                  |                  |       |
| 139-Expenses for other livestock (excl ruminants & pigs) + dogs, cats, etc      |                   |          |       |                  |                  |       |

**Frequency codes:** 1-Daily, 2-weekly, 3-monthly, 4-every 2 weeks, 5-every 2 months, 6-every 6 months, 7-quarterly, 8-annually, 9-bi-annually

## SECTION 14: Household Consumption Expenditure

14.1. On average, how many people were present in this household in the last 7 days (one week ago)? In this section children are defined as less than 18 years.

| Household Members |               |               |                 | Visitors    |               |               |                 |
|-------------------|---------------|---------------|-----------------|-------------|---------------|---------------|-----------------|
| Male adults       | Female adults | Male children | Female children | Male adults | Female adults | Male children | Female children |
|                   |               |               |                 |             |               |               |                 |

14.2 Consumption (Food, Beverage, and Tobacco) (During the Last 7 Days) (Note: Value = Price (market / farm gate) × Qty)

| Item Description       | Item consumed<br>1=Yes<br>0=No | Unit of Quantity | Consumption out of Purchases |       |                |       | Consumption out of home produce |       | Received in-kind/Free |       | Av. Market Price | Av. Farm gate price |
|------------------------|--------------------------------|------------------|------------------------------|-------|----------------|-------|---------------------------------|-------|-----------------------|-------|------------------|---------------------|
|                        |                                |                  | Household                    |       | Away from home |       |                                 |       |                       |       |                  |                     |
|                        |                                |                  | Qty                          | Value | Qty            | Value | Qty                             | Value | Qty                   | Value |                  |                     |
| Matoke (Bunch)         |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Matoke (Cluster)       |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Matoke (Heap)          |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Matoke (Others)        |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Sweet Potatoes (Fresh) |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Sweet Potatoes (Dry)   |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Cassava (Fresh)        |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Cassava (Dry/Flour)    |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Irish Potatoes         |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Rice                   |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Maize (grains)         |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Maize (cobs)           |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Maize (flour)          |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Bread                  |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Millet                 |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |

| Item Description       | Item consumed<br>1=Yes<br>0=No | Unit of Quantity | Consumption out of Purchases |       |                |       | Consumption out of home produce |       | Received in-kind/Free |       | Av. Market Price | Av. Farm gate price |
|------------------------|--------------------------------|------------------|------------------------------|-------|----------------|-------|---------------------------------|-------|-----------------------|-------|------------------|---------------------|
|                        |                                |                  | Household                    |       | Away from home |       |                                 |       |                       |       |                  |                     |
|                        |                                |                  | Qty                          | Value | Qty            | Value | Qty                             | Value | Qty                   | Value |                  |                     |
| Sorghum                |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Beef                   |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Pork                   |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Goat Meat              |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Other Meat             |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Chicken                |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Fresh Fish             |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Dry/ Smoked fish       |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Eggs                   |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Fresh Milk             |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Infant Formula Foods   |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Cooking oil            |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Ghee                   |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Margarine, Butter, etc |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Passion Fruits         |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Sweet Bananas          |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Mangos                 |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Oranges                |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Other Fruits           |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Onions                 |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Tomatoes               |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Cabbages               |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |

| Item Description               | Item consumed<br>1=Yes<br>0=No | Unit of Quantity | Consumption out of Purchases |       |                |       | Consumption out of home produce |       | Received in-kind/Free |       | Av. Market Price | Av. Farm gate price |
|--------------------------------|--------------------------------|------------------|------------------------------|-------|----------------|-------|---------------------------------|-------|-----------------------|-------|------------------|---------------------|
|                                |                                |                  | Household                    |       | Away from home |       |                                 |       |                       |       |                  |                     |
|                                |                                |                  | Qty                          | Value | Qty            | Value | Qty                             | Value | Qty                   | Value |                  |                     |
| Amaranthus (Dodo,Omuchicha)    |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Other vegetables               |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Beans (fresh)                  |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Beans (dry)                    |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Ground nuts (in shell)         |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Ground nuts (shelled)          |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Ground nuts (pounded)          |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Peas                           |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Simsim                         |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Sugar                          |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Coffee                         |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Tea                            |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Salt                           |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Soda*                          |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Beer*(local/bottled)           |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Other alcoholic drinks         |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Other drinks                   |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Cigarettes                     |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Other tobacco                  |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| Expenditure in Restaurants on: |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |
| 1. Food                        | 107                            |                  |                              | 5     |                |       |                                 |       |                       |       |                  |                     |
| 2. Soda                        |                                |                  |                              |       |                |       |                                 |       |                       |       |                  |                     |

| Item Description | Item consumed<br>1=Yes<br>0=No | Unit of<br>Quantity | Consumption out of Purchases |       |                |       | Consumption out of<br>home produce |       | Received in-kind/Free |       | Av.<br>Market<br>Price | Av. Farm<br>gate price |
|------------------|--------------------------------|---------------------|------------------------------|-------|----------------|-------|------------------------------------|-------|-----------------------|-------|------------------------|------------------------|
|                  |                                |                     | Household                    |       | Away from home |       |                                    |       |                       |       |                        |                        |
|                  |                                |                     | Qty                          | Value | Qty            | Value | Qty                                | Value | Qty                   | Value |                        |                        |
| 3. Beer          |                                |                     |                              |       |                |       |                                    |       |                       |       |                        |                        |
| Other juice      |                                |                     |                              |       |                |       |                                    |       |                       |       |                        |                        |
| Other foods      |                                |                     |                              |       |                |       |                                    |       |                       |       |                        |                        |

\* Sodas and Beers to be recorded here are those that are not taken with food in restaurants.

## SECTION 15: Household food insecurity access scale

I am going to ask you questions about your household's food supply over the past four weeks. Food supply includes staples, sauces, and any other foods in your diet and the diets of all members of your household.

### 15.1. Household Food Insecurity Access Scale

| No.     | Question (Response: 1=Yes; 0=No)   | No.     | Frequency [1 = Rarely (once or twice in the past four weeks)<br>2 = Sometimes (3 to 10 times in the past four weeks)<br>3 = Often (more than 10 times in the past four weeks)] |
|---------|--|---------|--|
| 15.1.1  | In the past four weeks, did you <u>worry</u> that your household would not have enough food?   | 15.1.2  | If yes, how often did this happen? .....   |
| 15.1.3  | In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources? .....                                      | 15.1.4  | If yes, how often did this happen? .....   |
| 15.1.5  | In the past four weeks, did you or any household member have to eat a limited variety of foods due to lack of resources? .....   | 15.1.6  | If yes, how often did this happen? .....   |
| 15.1.7  | In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of lack of resources to obtain other types of food? ..... | 15.1.8  | If yes, how often did this happen? .....   |
| 15.1.9  | In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food? .....                                 | 15.1.10 | If yes, how often did this happen? .....   |
| 15.1.11 | In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?  | 15.1.12 | If yes, how often did this happen? .....   |
| 15.1.13 | In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food? .....  | 15.1.14 | If yes, how often did this happen? .....   |
| 15.1.15 | In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food? .....   | 15.1.16 | If yes, how often did this happen? .....   |
| 15.1.17 | In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food? .....                                    | 15.1.18 | If yes, how often did this happen? .....   |

### 15.2. How do you cope with situations of lack/scarcity of food? (Multiple choice)

1-Do nothing / stay hungry; 2-Rely on food aid; 3-Borrow from friends / relatives; 4-Work for food / money; 5-Reduce on no. meals; 6-Reduce the quantity of food prepared; 991-other, specify

15.3. What is the average number of meals per day in your household in the last 4 weeks? \_\_\_\_\_

## SECTION 16: Infrastructure and institutional support services

### Institutional Interventions or services in place

| Institutions/service         | Is this service/intervention available in your area? 1=Yes<br>0=No | Do you or any member of the household have access to this service<br>1=Yes<br>0=No | Distance from your home to the nearest point of access to this service (in KM) | Was any member of the household in need of this service in the last 12 months?<br><br>1=Yes; 0=No | Did any of the household members participate or access services from this institution in the last 12 months?<br><br>1=Yes; 0=No | Who in the household directly participated or accessed this service?<br>(multiple)<br><br>1=husband; 2=wife;<br>3=mother; 4=father;<br>5=grandfather;<br>6=grandmother; 7= male child; 8=female child; 991=other, specify | No. of times the household has been in contact with the institution that provides this service in the last one year? | Who is responsible for facilitating access to this service/intervention?<br><br>1=The community;<br><br>2. NAADS; 3=NGOs*;<br><br>4=Private sector;<br>5=FAO; 6=NARO/TARI<br><br>7=Others (specify) | If NGO, please specify |
|------------------------------|--|--|--|---|---|---|--|---|------------------------|
| Extension Services           |  |  |  |   |   |   |  |   |                        |
| Development Agencies (NGOs)  |  |  |  |   |   |   |  |   |                        |
| Agricultural product markets |  |  |  |   |   |   |  |   |                        |
| Livestock                    |  |  |  |   |   |   |  |   |                        |
| Agricultural input markets   |  |  |  |   |   |   |  |   |                        |
| Planting material            |  |  |  |   |   |   |  |   |                        |
| Community health services    |  |  |  |   |   |   |  |   |                        |
| Human nutrition services     |  |  |  |   |   |   |  |   |                        |
| All-weather road (tarmac)    |  |  |  |   |   |   |  |   |                        |
| Credit facilities/Banks      |  |  |  |   |   |   |  |   |                        |

**NGOs include:** CARITAS, World Vision, Plan International, VEDCO, RUHEPAI, HRNS, KRC, etc.

## SECTION 17: Impact of COVID 19 and other shocks

1. Did any member in this household contract COVID-19 disease? (1=Yes, 2=No)
2. If yes, how many members contracted COVID-19 disease?
3. Did this household lose any member, relative or close friend to COVID-19 disease? (1=Yes, 2=No).
4. If yes, how many members succumbed to COVID-19 disease?
5. Has any member in this household accessed any of these interventions to help them prevent or cope with the effects of the COVID-19 pandemic?
  - i. Face masks
  - ii. Relief food
  - iii. Cash
  - iv. Vaccination
  - v. COVID treatment
  - vi. None
  - vii. Other specify

### Shocks and Coping Strategies (COVID 19 & Climate Change Questions)

| Code | Description of distress events   | Did you experience [SHOCK] during the past 24 months?<br>1=Yes;<br>2=No | When did the [SHOCK] first occur?<br>1=Jan 7=Jul<br>2=Feb 8=Aug<br>3=Mar 9=Sept<br>4=Apr 10=Oct<br>5=May 11=Nov<br>6=Jun 12=Dec |     | How long did the [SHOCK] last?<br>(Record No. of Months. If less than one month record 00) | As a result of the [SHOCK] was there a decline in your household's [...]? |        |                 |                | How did your household cope with this [SHOCK] |                 |                 |
|------|--|---|---|-----|--|---|--------|-----------------|----------------|---|-----------------|-----------------|
|      |  |   | M   | YYY |  | Income  | Assets | Food production | Food purchases | 1 <sup>st</sup>                               | 2 <sup>nd</sup> | 3 <sup>rd</sup> |
|      | A1   | 1   | 2A  | 2Y  | 2B   | 3A  | 3B     | 3C              | 3D             | 4A  | 4B              | 4C              |
| 01   | Loss of employment of previously employed (wage or salaried) household member(s) due to COVID-19 disruptions |   |   |     |  |   |        |                 |                |   |                 |                 |
| 02   | Reduction of earnings of currently (off-farm) employed household member(s)                                   |   |   |     |  |   |        |                 |                |   |                 |                 |
| 03   | Serious illness of income earner(s) from other diseases  |   |   |     |  |   |        |                 |                |   |                 |                 |
| 04   | Serious illness of other household member(s) from other diseases   |   |   |     |  |   |        |                 |                |   |                 |                 |
| 05   | Death of income earner(s)  |   |   |     |  |   |        |                 |                |   |                 |                 |

#### Codes for Col 4A, 4B, 4C

1=Unconditional help provided by relatives/friends  
 2=Unconditional help provided by local government  
 3=Changed dietary patterns involuntarily (Relied on less preferred food options, reduced the proportion or number of meals per day, skipped days without eating, etc)  
 4=Changed cropping practices (crop choices and technology)  
 5=Household member(s) took on more non-farm (wage- or self-) employment  
 6= Household member(s) took on more farm wage employment

|     |  |  |  |  |  |  |  |  |  |  |  |  |   |
|-----|--|--|--|--|--|--|--|--|--|--|--|--|---|
| 06  | Death of other household member(s)   |  |  |  |  |  |  |  |  |  |  |  | 7=Household member(s) migrated                                      |
| 07  | Increase in intra-household disagreements  |  |  |  |  |  |  |  |  |  |  |  | 8=Relied on savings   |
| 08  | Unusually high transport costs or lack of transport                                      |  |  |  |  |  |  |  |  |  |  |  | 9=Obtained credit   |
| 09  | Unusually high costs of household foodstuff  |  |  |  |  |  |  |  |  |  |  |  | 10=Sold durable household assets (agricultural or non-agricultural) |
| 10  | Ripening/wastage of produce due to transport disruptions                                 |  |  |  |  |  |  |  |  |  |  |  | 11=Sold land/building   |
| 11  | Scarcity of produce-buyers   |  |  |  |  |  |  |  |  |  |  |  | 12=Rented out land/building   |
| 12  | Difficulty in accessing inputs   |  |  |  |  |  |  |  |  |  |  |  | 13=Distress sales of animal stock                                   |
| 13  | Difficulty in accessing produce markets  |  |  |  |  |  |  |  |  |  |  |  | 14=Sent children to live elsewhere                                  |
| 14  | Unusually high costs of agric inputs   |  |  |  |  |  |  |  |  |  |  |  | 15=Reduced expenditures on health                                   |
| 15  | Unusually low prices of agric output (produce)   |  |  |  |  |  |  |  |  |  |  |  | 16=Reduced expenditures on education                                |
| 16  | Disruptions in farm activities (e.g. delayed planting, lack of access to the farm, etc.) |  |  |  |  |  |  |  |  |  |  |  | 17=Reduced expenditures on foodstuffs                               |
| 17  | Drought  |  |  |  |  |  |  |  |  |  |  |  | 18=Reduced hired-labour on-farm                                     |
| 18  | Irregular rains  |  |  |  |  |  |  |  |  |  |  |  | 19=Household member(s) started a business                           |
| 19  | Floods   |  |  |  |  |  |  |  |  |  |  |  | 20=Started rearing animals  |
| 20  | Landslides   |  |  |  |  |  |  |  |  |  |  |  | 21=Reduced movement   |
| 21  | Erosion  |  |  |  |  |  |  |  |  |  |  |  | 991=Other (specify)   |
| 22  | Crop pests & disease outbreaks (e.g African Army worm, banana thrips)                    |  |  |  |  |  |  |  |  |  |  |  |   |
| 23  | Unusually high level of livestock disease outbreaks                                      |  |  |  |  |  |  |  |  |  |  |  |   |
| 991 | Other (specify)  |  |  |  |  |  |  |  |  |  |  |  |   |

***Thank you very much for your cooperation.***