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Sugarcane Production and Food Security in Uganda

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ABSTRACT

The study analyses the relationship between households' participation in sugarcane production and food security in Uganda's major producing subregions of Buganda, Busoga and Bunyoro. Using primary data collected from 1,771 households and group discussions, the study uses three different measures of food security -- Household Food Insecurity Access Score (HFIAS); Months of Adequate Household Food Provisioning (MAHFP); and Household Dietary Diversity Score (HDDS) to lay a picture into this sugarcane -food security nexus. Findings revealed higher average HFIAS, MAHFP and HDDS values for cane-growing households compared to non-cane growers. Poisson estimates of the three food security scores and an Ordered Probit Model of Food Insecurity Scale, derived from HFIAS found that farm households engaging in cane production in 2021 had lower levels of food insecurity and a higher number of months of food adequacy on average, relative to households not producing cane, while controlling for other factors known to influence household food security. Other factors such as the dependence on unstable wage income, faith in indigenous religions, large family size, and shocks like crop pests and diseases, being resident in Busoga and Bunyoro sub-regions compared to Buganda led to increased food insecurity. On the other hand, better access to food and a household having more months of adequate food provisions improved in male-headed households, households headed by persons of reasonable age, a stable annual salary income; maximum education of female adults; the number of livestock owned; the value of household assets; and the number of food crops grown. The study finds no significant effect of cane production on HDDs. Food insecurity score increased for households in which decision-making on crop choices on what to plant on plots was done jointly (both male and spouse) and only female head/spouse with no significant effect of decision making on crop marketing and income from sales on food security. Therefore, there is a need to design spatial programmes for Busoga and Bunyoro to enhance food security and at the same time pay special attention to integrating human capital development, especially for females, wealth creation, and crop diversification. In addition, there is a need to guide farming households on enterprise selection that matches with available arable land size. Farmers with the intention of growing cane should have a minimum of 8-15 acres under intensive cane production with a minimum of 1-2 acres under food.

Keywords: Sugarcane production, food security, decision making, Poisson model

1. INTRODUCTION

Agriculture is fundamental to food security by making more food available or by enabling farm households to access food using their farm income. The UN 2030 agenda on Sustainable Development Goal (SDG) 2 is to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture as well as promoting inclusive and sustainable industrialisation and foster innovation (UNDP, 2015). FAO et al. (2022) highlight that in 2021, 9.8% of the World, 20.2% of Africa, 23.2% of sub-Saharan Africa (SSA) and 29.8% of Eastern Africa people were undernourished. Further, 30% of the global population were moderately or severely food insecure, with close to 40% faced with food insecurity at severe levels. Africa region had the highest prevalence at moderate or severe food insecurity levels (ibid). According to the Economist Intelligence Unit (EIU)'s Global Food Security Index (GFSI) 2022 report, Uganda is ranked in the 93rd position out of 113 countries on food affordability, availability, quality, and safety. The EIU GFSI score for the World is 62.2%, in which SSA region had the lowest score-47%.

Seasonality in rainfed food production (Blackmore et al., 2021), earning patterns (Cordero-Ahiman et al., 2021), and variability in food prices (Brown, 2014) are often related to the presence of climate change phenomena that impact food security (Affoah et al. 2022). In addition, unemployment, and underemployment (leads to working poor class) with an equally increasing absolute number of the population who are income poor, are affecting the ability of households to access healthy and nutritious food due to a reduction in family income and high age dependency ratios (WFP, 2020). Beyond these, concerns have been raised that cash crop farming such as sugarcane growing could have adverse effects on food security[1] of local communities and households in which such an activity is taking place. Insights into cane reveal that large scale sugarcane farmers and nucleus farms come with mixed blessing (Fitawek and Hendriks, 2021; Herrmann, 2017). These acquire large pieces of land from communities with adverse spillovers effects on local communities' food security (Aabø and Kring,2012; Fitawek and Hendriks, 2021; Lisk, 2013; Herrmann, 2017; Nolte and Ostermeier, 2017). At the same time provide employment and income to the same communities (Fitawek and Hendriks, 2021), improve infrastructure (including roads), increase production and access to farm inputs and modern technologies that foster development and food security (Burnod et al., 2015; Hall, 2017; Zaehringer, 2018 (a &b)). Despite the intense demands on natural resources, cane production also links small-scale farmers to value chains through institutional arrangements. Therefore, sugarcane is considered a "high impact"[2] crop in relation to both water and labour (Hess et al., 2016).

In Uganda, especially rural areas, households' access to food largely depends on what they grow, either because they consume what they grow, or purchase food with the income earned from what they grow. Such that food insecurity in Uganda is primarily derived from dependence on undiversified livelihoods with heavy reliance on rain-fed agriculture (EPRC, 2018). Like most parts of the country growing cash crops, the sugarcane growing regions are experiencing increasing income poverty and food insecurity (UBOS, 2021). Most households both sugarcane and non-sugarcane growers are encouraged to diversify crop production to ensure sustained food stocks and incomes. Evidence partly shows that crop diversification enhances food security and dietary diversity, particularly when the level of production diversity is low to begin with (Appiah-Twumasi and Asale 2022; Mengistu et al., 2021; Douyon et al., 2021; Sibhatu and Qaim, 2018; Sibhatu et al., 2015; Pellegrini and Tascotti, 2014; Njeru 2013).

Over the last six decades, Uganda's sugarcane industry has grown mainly through increased area cultivated, increasing total sugar production from 1 million to over 5 million tons (FAO, 2020; Mbowa et al., 2022). However, empirical evidence remains scanty on how sugarcane production expansion affects food security and gender equality and under what conditions. Studies like Kennedy (1989) and Mwavu et al. (2018) find that sugarcane growing increases

1 Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). Food security comprises four major components and these include availability, access, utilization and stability (FAO 2008). These components explain whether a household has a sufficient quantity of food with the required food nutrients, in the right social, economic, political and traditional environment to ease food acquisition observing good food hygiene at all times.

2 High impact refers to a crop associated with significant positive and/or negative environmental and/or socio-economic impacts.

farm household income and thus could increase food security through an income pathway. However, Waibi (2019) finds that a Ugandan sugarcane farmer with less than ten acres of land is more vulnerable to food insecurity. The study stresses that this is caused by most of the farmers allocating more land to sugarcane growing than food crop which undermines household food availability and stability. Further, these leave small plots of land for food crop growing and use poor farming methods which lead to low crop yields hence causing food shortage. In considering gender, Adams et al. (2019) note that contract farming in sugarcane production exacerbates gender inequality in terms of access to land, household labour relations and participation in production and marketing decisions. Such dynamics ultimately impact household food security and nutrition given women's important roles in agricultural production and domestic decisions around food sourcing and preparation.

Available studies from East Africa on the relationship between commercial crop farming and food security in Kenya (Kirimi et al., u.d), Tanzania (Dancer and Sulle, 2015) and Uganda (Waibi, 2019; Mwavu et al., 2018) have used mainly descriptive statistics and single measures of household food security (Kipkorir, 2023; Kirimi et al. u.d), with mixed findings. In addition, studies that have investigated the food security status of sugarcane growing households in Uganda have not compared them with non-cane growers within the same communities. This paper aims to address this local evidence gap and the inconclusive research findings from East Africa by investigating the relationship between cane production and household food security within Uganda's three main cane growing regions. It also contributes to the decades-long debate on the relationship between cash crop production and household food security in a developing country context, with a focus on sugarcane production and household food security.

Consequently, the overall objective of this paper is to examine the effects of sugarcane production on food security in Uganda. More specifically, this paper addresses three main research questions. First, is participation in cane production in Uganda associated with better food security outcomes? Second, do differences in institutional arrangements between cane growers and millers influence the relationship between participation in cane production and household food security? Third, does women's influence in intra-household decision-making regarding crop choice, crop market participation (i.e. retention and/or sale of harvested crops), or the allocation of crop sales income influence household food security, and does this relationship differ between households that grow cane and those that do not?

The paper posits the following hypotheses for these research questions:

(i) Sugarcane growing households have better food security outcomes than non-sugarcane growing households.

(ii) Cane growers that are registered and aided have better food security outcomes than cane growers who are not.

(iii) Households where the female head/spouse has significant influence on intra-household decision-making regarding crop choice, crop market participation, and the allocation of crop sales income have better food security outcomes, all else constant.

To address the above research questions the paper addresses the following key questions: In terms of

a. *Context*- does sugarcane production affect food security in sugarcane growing regions?

b. *Livelihoods* – What determines food security status among households in sugarcane growing sub regions?

c. *Institutional arrangements*– What is the relationship between miller-outgrower arrangements on food security status of a sugarcane growing household.

d. Participation – To what extent does women's influence on intra-household decision-making affect food security outcomes, and does this relationship differ between cane and non-growers?

This study is based on primary data collected in November/ December 2021 from 1,771 cane growing and non-growing households in Buganda, Busoga and Bunyoro subregions. Information from focus group discussions with cane growers and key informant interviews with large and small cane mills, cane grower associations, and relevant government officials contributed to the study analysis.

The rest of this paper is organized as follows. Section 2 provides a literature review on sugarcane and food security. Section 3 then describes the methods and data used to address the research questions. Section 4 provides research results and discussion, followed by conclusions and policy implications in Section 5

2. LITERATURE REVIEW

This section provides review of literature on the relationship between sugarcane production, governance between millers and outgrowers and the gendered effects arising from production and marketing on household food security. Such insights were needed to guide the analytical strategy for the paper, including the specification of multivariate regressions of the different measures of household food security.

2.1 Effects of growing sugarcane on household food security

Household food security is a multidimensional concept, it depends on multiple factors such as the stability of food supply, household food production, access to food through income, prevailing food prices and the availability of food in markets. There has been a long-standing debate and literature over the past thirty years addressing the question of whether smallholder participation in contract farming (CF) arrangements results in positive or negative changes in household welfare in practice. An extensive review of the literature by Otsuka, Nakano and Takahasi (2016) found that in most cases, CF improved farmers' income by introducing them to higher-return crops and yield-improving production technologies. However, some recent studies find no relationship between CF and household welfare or a negative one (Ragasa et al, 20180, while another recent review of CF studies argued that the evidence remains inconclusive because too few of the existing studies used methods that were appropriate for making causal claims (Bellemare, 2018).

Among research focused on sugarcane and household welfare, some studies find positive effects or associations of cane production with improved household and community measures of wellbeing, while other find negative associations. For example, Martinelli et al. (2011) examined how human development indicators (HDIs) varied across municipalities with different levels of sugarcane production in Sao Paulo, Brazil, and found a statistically significant relationship between the presence of a strong sugar and ethanol industry and higher levels of economic and social development. Municipalities with a sugar mill, on average performed better on human development over the past decade than those without a sugar mill. Sugarcane is often grown next to factory/mill sites resulting in a need for significant infrastructural development, such as housing, roads, schools, and medical facilities for people involved in the production and processing of cane. For sugarcane production to be sustainable, the sector should not only increase the employment and income potential of the farmers, but also contribute to overall well-being such as in food security and health (El Chami et al., 2020). However, some agricultural practices in sugarcane farming may cause health problems such as excess risk of respiratory diseases. For example, pre-harvest burning of sugarcane straw is significantly associated with higher rates of hospital admissions for respiratory diseases in children under five years old in Brazil (Paraiso and Gouveia, 2015).

Martiniello and Azambuja (2019) find that sugarcane contract farming schemes are associated with an increase in food insecurity among rural households in Eastern Africa. The authors attribute this in part to land conversion from food crops to sugarcane. In addition, farmers tend to allocate most of their land to sugarcane cultivation in the hope of maximizing monetary revenues, at the expense of more traditional food crops production. In Thailand, Intarapoom et al. (2018) examined the impacts of sugarcane farmland expansion on the four dimensions (food availability, access, utilization, and stability) of food security among the sugarcane-farming households. Results showed that increasing land allocation to cane production was associated with the lowest food security when compared to households that did not convert their land into cane production.

In Uganda, Mwavu et al. (2018) assessed the contribution of commercial sugarcane production on household level food security among smallholder farmers in the Busoga sub-region (jinja and Mayuge districts), a major sugar-producing region in Eastern Uganda. They find that 87% of the respondents, and 7 in every 10 households of commercial sugarcane growers were lacking adequate and nutritious food in their households in the last 12 months prior to the study. Most households grow few food crop varieties and have inadequate income to purchase food to meet their needs or supplement what they grow. They conclude that sugarcane cultivation may be a key driver of food insecurity in Uganda -- despite the perception that it offers benefits of poverty alleviation and improved human and social welfare at household and community levels (Mwavu et al., 2018). Similarly, Lwanga et al. (2015) also conducted a cross-sectional study on households in Nabitambala parish,

Eastern Uganda, and find that only 12% of households were food secure while 49.7% were severely food insecure. By contrast, Ahmed et al. (2019) find that despite the lack of a stable market, sugarcane smallholders in Ghana have lower levels of multi-dimensional poverty and higher levels of income than the control group, and income obtained through sugarcane cultivation is higher than that of food crop farming. However, the higher levels of objective well-being do not translate into higher levels of subjective well-being such as satisfaction of life and happiness.

Yet, it is important to note that because the two Uganda studies above interviewed only sugarcane growers, they were not able to assess whether cane growers in these areas have better, worse, or similar food security outcomes to non-growers. The answer to that question is important because food insecurity among some cane growers does not necessarily mean that participation in cane production has caused that food insecurity; the root cause of a household's food insecurity could be factors common to other households in the community and/or specific to the household in question.

2.2 Institutional arrangements between millers and sugarcane out-growers and household food security

Contract farming and other institutional arrangements vary greatly as they have different underlying structures, terms, and conditions. This implies that the differences in institutional arrangements between millers and growers will have various implications on the welfare and household food security of cane producers in different areas. Additionally, as outgrower schemes are used as a mechanism to commercialise small-scale farming, the impact of sugarcane farming on farmers' incomes depends on multiple factors. These include the income generating potential of the land, size of the farm, practices adopted by the farm and other institutional, local, and social contexts (Herrmann et al., 2018; Wendimu et al., 2016; Aleme, 2019).

For example, Herrmann et al. (2018) in Malawi compares the food security between outgrowers and non outgrowers and find that outgrowers earn significantly higher incomes and allocate more land to food crops. In areas with compulsory participation in sugarcane outgrower schemes in Ethiopia, Wendimu et al. (2016) find that participation in outgrower schemes has a significant short and long run negative effect on the income and, a significant long-run negative impact on asset stocks of outgrowers whose land had a high potential for income generation prior to participation in sugarcane schemes. Additionally, food security in outgrower villages declined over time but improved in non outgrower villages mainly due to less land allocation to food crops. Notably, crop diversity improves welfare and food and nutrition management in rural households (Tesfaye and Tirivayi, 2020). Therefore, the opportunity cost of the land was too high to have a positive impact on welfare. Similarly, Aleme (2019) use a computable general equilibrium model and also conclude that there is a strong trade-off between sugarcane plantation and household welfare, represented as income and expenditure, in Ethiopia. On the other hand, Dam Lam et al. (2017) find that sugarcane farmers in Ethiopia have a lower prevalence of undernourishment and poverty levels.

Contrastingly, in Zambia, cane outgrowers have access to better water facilities, electricity, and more income earnings. However, they have more debts compared to the non-cane growers. Also, the food security of cane growers was higher at 74.3% than non-cane growers at 46.9%. Overall, Bubala et al. (2018) find that sugarcane growers participating in the outgrowers scheme were far better off than non-outgrowers and non-cane growers as it ensured improved livelihood and food security. These differences across studies raise important questions about the different institutional arrangements and other contextual conditions that determine the food security and welfare benefits of sugarcane growers.

2.3 Sugarcane production, women's influence on intra-household decision-making in crop production and marketing, and household food security

Research has found that when households shift more of their land into cash crops, this has sometimes resulted in women in those households having less control than before over intra-household decisions on crop choice, crop marketing, and control over income from crop sales (Andersson Djurfeldt, 2018; Fischer and Qaim, 2012). The reason that this may happen is due to the gendered nature of women and men's roles in farm production and marketing activities in much of sub-Saharan Africa. For example, women often engage in and manage activities such as weeding, harvesting, processing, and storage of food crops, while

men often control the production and marketing of cash crops as well as the marketing of surplus food crops (von Braun *et al*, 1995; Ellis *et al*, 2007; Mashma, Thebe, and Uzokwe, 2018). Thus, if a household decides to join a cash crop outgrower arrangement, this may result in one or more household parcels previously used by women for food crop production being shifted by a male household head into cash crop production.

Yet, women's empowerment in such intra-household decisions is important because it can have a positive effect or household food security and nutrition. This is demonstrated by evidence from Africa showing that women are more likely than men to spend additional income under their control on food for the household and on increased diet diversity (Hoddinott and Haddad, 1995; Duflo and Udry, 2004; Fischer and Qaim, 2012; Ogutu *et al.*, 2020; Nikiema and Sakurai, 2021). Thus, while increased crop income per acre from a cash crop has the potential to improve household food security, it is not a given and may be influenced by the extent of women's influence in intra-household decision-making regarding how such additional income is used and how much of the household's land is shifted out of food crop production. For this study, we explore whether women's influence on intrahousehold decisions regarding household crop choice, crop marketing decisions, and allocation of income from crop sales is associated with household food security outcomes.

Another gendered aspect of cane production in Uganda is what kinds of households can participate in cane production and thus, its expected direct benefits. It is important to note that there is considerable heterogeneity among smallholder farmers in Uganda and throughout Africa in their resource endowments, such as land control, labour conditions, asset ownership, financial and social capital, and access to services (Hall *et al.*, 2015). Participation in a cane outgrower scheme is often not possible for farmers with limited landholding and financial resources, given minimum acreage requirements that sugar mills often prescribe for inclusion in their outgrower schemes as well as financial resources that farmers need to grow cane. Subsequently, Female-headed households and women often face more constraints than adult male farmers to participation in cane outgrower schemes. An implication of this is that female-headed households are less likely to be able to participate in and thus benefit from higher net income per acre from cane production, which is one pathway a household may increase their food security.

Gender gaps in agricultural production arise because women generally have less access to productive assets, like land; agricultural inputs, including family labour; and services such as credit and extension. These gender inequalities are underpinned by harmful gender norms which restrict women's access to land, credit, and extension and financial services, which subsequently constrain their roles within different livelihood and economic opportunities within agrifood systems. Women in most Sub-Saharan countries predominantly participate in less remunerative farm and nonfarm activities due to these factors. For example, in Kakamega, Kenya, sugarcane is a major cash crop, and most farmers are outgrowers. Outgrowers must own land but based on Abaluya cultural norms, most women are unable to become outgrowers due to lack of control and ownership of land (Loison, 2019). In Zambia, land ownership is crucial in determining smallholder cultivation of sugarcane (Manda et al., 2020). Each household is required to hold a maximum of 4 hectares of land in the sugarcane catchment area. This implies that the landless, land scarce and marginal land-owning households are excluded, including the poor who cannot afford to purchase land in the scheme catchment area. These are mainly women, the aged, widows and youths. Some of these contexts are similar to what is in Uganda.

In Jinja, eastern Uganda, a study on smallholder sugar producing households found that most cane contract farmers are men, so most of the income is paid directly to men (Ambler et al. 2021). Additionally, women spend more time working on non-cane agriculture and 4-5 times more time on household management and chores (ibid). An intervention in this area encouraged couples to register a block of cane in the wife's name, effectively transferring an asset (and potential income) from the husband to the wife. The study found that 70% of invited households accepted the offer to register cane blocks in the wife's name and acceptance was even higher among households randomly selected to attend a couple's workshop focused on gender equity and balance within the household. The study also finds that low socioeconomic status and household gender norms that prevent women's economic participation in the sugarcane value chain acted as barriers to the household's acceptance of the contract intervention.

3. METHODOLOGY

This study used primary data (qualitative and quantitative from Uganda's sugarcane-growing sub-regions collected by the Economic Policy Research Centre (EPRC), Uganda in the context of the Innovations Lab for Food Security Policy, Research, Capacity, and Influence (PRCI) project. This section provides detailed information on the description of the study areas, data collected and data analysis methods.

3.1 Description of study areas

Sugarcane production in the sub-regions of Buganda[3], Busoga[4] and Bunyoro[5] is dominated by three (3) historical mills with nucleus farms. These also relay on outgrowers to fill the supply gap. Agriculture in Uganda contributes about 23% of GDP (UBOS, 2022) and employs over 70% of the labour force excluding subsistence farming (UBOS, 2021). Crops grown vary across the three sub regions. Maize, sweat potatoes, groundnuts are the main crops cultivated in Busoga; maize, cooking banana in Buganda while in Bunyoro, maize, beans, cassava, nuts (UBOS, 2021). In all the three sub regions sugarcane growing is the predominant cash crop grown by majority of small holder farmers.

3.2 Study design and sample selection

The EPRC-PRCI project selected three sub regions (Buganda, Busoga, and Bunyoro) in Uganda for several reasons. First these, are the regions with historical districts that started sugarcane growing in Uganda with the three largest nucleus farm estates. Second, these regions also have well established large mills, recognised, and organised out-grower-miller arrangements with massive expansion plans. Busoga and Bunyoro sub regions also had increasing income poverty (UBOS, 2021), partly attributed to sugarcane growing by households. Furthermore, these have the number of households that potentially are food secure affected from sugarcane growing (directly or indirectly). Lastly, no comprehensive study on sugarcane growing effects on food security has been conducted in these sub regions with national representation.

The study used a three-stage sampling design. In the first stage, sub-counties were randomly selected in each of the 16 districts who were major sugarcane growers. From the selected sub-counties, a total of 120 villages were randomly selected using probabilities proportional to size (PPS). Next, for all the selected villages, a listing of all the farming households were conducted where information on whether a household grows cane, and cane production arrangements were collected. The listing also captured information on whether cane growing households have cane plots that are owned by women, sex of the household head, and key decision-making indicators by gender to allow for sampling that supports gender analysis.

Sampling within a village first involved stratification of farmers into two categories: cane growers and non-cane growers. Next, cane growers were also categorized by their institutional arrangement with a nearby mill: registered and aided[6], registered and not aided, and unregistered and unaided growers. The listing and stratification were followed by random selection of 20 households (15 sugarcane growers, and 5 non-sugarcane growers) from each of the selected villages.

3.3 Data and variables

The primary data were collected using a combination of qualitative and quantitative methods. From a quantitative approach, the data is from a cross-sectional survey of farm households and communities in Uganda collected in December 2021. The survey targeted Uganda's main sugarcane growing sub-regions—Busoga, Buganda and Bunyoro, and collected quantitative data using a semi-structured questionnaire at the parcel-, household-, and community-levels. It used the 2014 Uganda Population and Housing Census sampling frame to select a representative sample of cane and non-cane growing households from these sub-regions.

3 Buganda we sampled mainly districts from Buganda North: Buikwe, Buvuma, Kayunga, Kiboga, Kyankwanzi, Luwero, Mityana, Mubende, Mukono, Nakaseke, Nakasongola, Kassanda

4 Busoga sub region districts include: Bugiri, Namutumba, Buyende, Iganga, Jinja, Kaliro, Kamuli, Luuka, Mayuge, Namayingo, Bugweri, Jinja City.

5 Bunyoro subregion districts include: Buliisa, Hoima, Kibaale, Kiryandongo, Masindi, Kikuube, Hoima City, KItagwenda

6 Registered implies that the grower and mill have a written or oral agreement prior to a grower's initial harvest, regarding the area of harvested cane the grower commits to sell to the mill, and which the mill likewise commits to purchase from the grower. The agreement also usually specifies how a mill's purchase price will be determined at time of delivery of cane to the mill. Aided means that a mill and grower agree that the mill will provide the grower with inputs such as inorganic fertilizers and planting material, typically on credit, on the condition the grower commits to deliver the agreed area of harvested cane to the mill at harvest, whereby the mill the cost of inputs provided on credit by deducting their cost from the gross value of the cane the grower delivers to the mill.

Within each sub-region, data was collected from the 16 sugar growing districts that have at least one milling factory, as cane growing farmers are nearly always concentrated near a milling factory. The reason for this is because harvested sugarcane is both highly perishable and has a low value to weight ratio, which means in practice that cane production is only profitable for farmers if it is grown relatively close to a mill. Detailed information on household demographics, food security, land management and community characteristics were collected for both cane and non-cane growers. Out of 2,400 households listed, 1,800 were surveyed and 1,771 had complete household information from 72 communities from which analysis was done. Households were classified as cane growers where the head was currently growing cane and non-cane grower where household heads did not grow cane. A binary variable (1 for cane growers and 0 for non-cane growers) was used for this categorisation. Note that analysis is at the household level unless otherwise stated. In addition, weights were applied to ensure that data is nationally representative.

For the qualitative approach, key informant interviews were conducted with community leaders, district agricultural officers, and two community barazas were conducted to share on food security vs sugarcane production. Focus Group Discussions (FGDs) were also conducted with separate groups of males and females on the issues related to sugarcane production, challenges, opportunities, and implications for food security in the community and households. Twenty-one FGDs and 19 KIIs were conducted.

3.3.1 Measuring household food security (outcome variable)

Food security is a complex issue that cannot be measured by one indicator alone. In this analysis, we used the definition of food security from the Food and Agriculture Organization of the United Nations (FAO), in which food security is divided into four dimensions: physical availability of food, economic and physical access to food, food utilization and the stability of these three dimensions over time (FAO, 2008). In this study, household food security indicators (availability, access, utilisation, and stability) were measured using three food security indicators of the months of adequate household food provision (MAHFP), household food insecurity access score/scale (HFIAS) and the household dietary diversity score (HDDS) as summarised in Table 1.

Table 1: Summary of food security indicators used in this study

Indicator	Recall period	Description	Source
Household Food Insecurity Access Score/ Scale (HFIAS)	30-days/4 weeks/ 1 month	The HFIAS is a continuous measure of the degree of food insecurity (access) in the household on the past 30 days. It also reflects the three universal domains of household food insecurity, insufficient quantity, and insufficient quality of food supplies. This indicator captures the household's perception about their diet regardless of its nutritional composition. The HFIAS value ranges from 0-27 for the nine-food insecurity related conditions. At a household level, a high HFIAS shows that a household is very food insecure, while a low score shows that a household is less food insecure. HFIAS is also measured on a scale of 0-3.	Coates, J., Swindale, A, and P. Bilinsky (2007). Household Food Insecurity Access Scale (HFIAS) for Measurement of Household Food Access: Indicator Guide (v. 3). Washington, D.C.: FHI 360/FANTA.
Household Dietary Diversity Score (HDDS)	24-hours	HDDS is a measure of diet quality and quantity, capturing the number of food groups consumed in the last 24 hours at either household or individual level. It is calculated by summing the number of unique food groups consumed during the last 7 days. The value ranges from 0-12, in which the lowest HDDS value signifies higher food insecurity status and vice versa. The HDDS denotes 12 food groups. These are: Cereals, roots and tuber, vegetables with tubers, leafy vegetables; fruits; meat, poultry; eggs; fish; legumes/nuts/seed; milk and milk products; oil/fats; sweets (sugar/honey) and, spices, condiments, beverages.	FANTA (Food and Nutrition Technical Assistance Project) (2006). Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access: Indicator Guide (Version 2); FANTA: Washington DC, USA, 2006

Months of Adequate Household Food Provisioning (MAHFP)	12-months	The MAHFP measures household food access and availability above the minimal level of the year. The indicator is the sum of the months of adequate provision.	Bilinsky, P and A. Swindale (2010). Months of Adequate Household Food Provisions (MAHFP) for Measurement of Household Food Access: Indicator Guide; Version 4: Food and Nutrition Technical Assistance II Project (FANTA): Washington, DC, USA, 2010

Source: Kolog, Asem and Mensah-Bonsu (2023) and

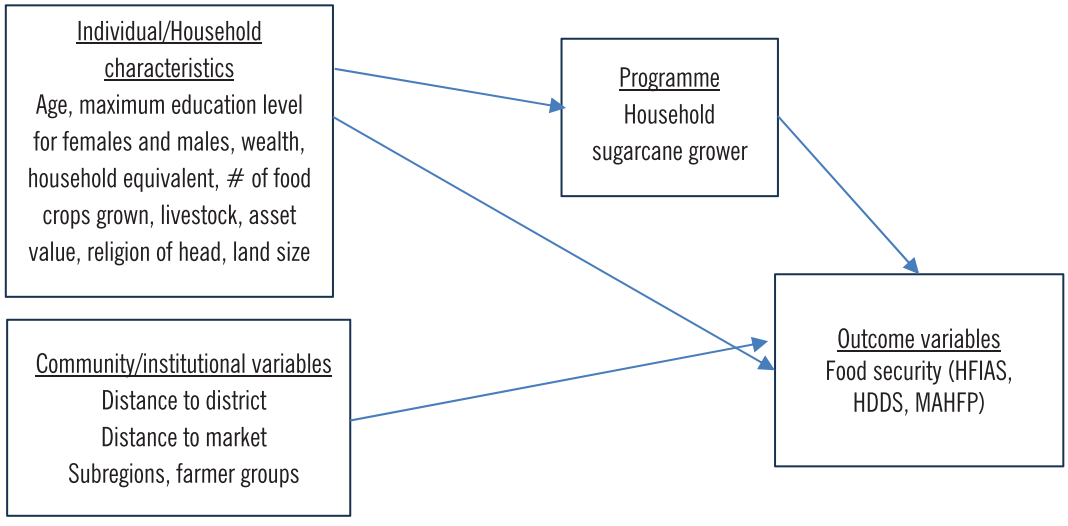
To assess the utilisation dimension, we used the household dietary diversity score (HDDS), which counts the number of different food groups the household consumed to a maximum of 12 food groups (Swindale and Bilinsky, 2006). It is based on consumption during the last week reported by the households during the household survey. The HDDS is a good indicator of food access (Swindale and Bilinsky, 2006) but is correlated with micronutrient deficiency (Hatløy et al., 2000). However, food utilization is described not only by access to micronutrients but also by how the body makes use of them (FAO, 2008). This is strongly influenced by the health status of household members, especially the status of the digestion system. We do not account for this variable as our data did not collect it.

The month of adequate household good provisioning (MAHFP) indicator was used to *assess the stability* dimension of food security because the MAHFP reflects the stability of a minimum food supply throughout the year (Bilinsky and Swindale, 2010; Coates, 2013). The MAHFP counts the number of months in the last year in which the household had enough food available (Bilinsky and Swindale, 2010). It thus ranges from 0 to 12. This indicator is relatively subjective because it is up to the respondent to decide how much food he or she considers as enough. Lastly, the Household Food Insecurity Access Scale (HFIAS) was used to assess the access to food and availability.

3.3.2 Conceptual framework –Sugarcane growing and other determinants of household food security

In a binary case, the programme is one if the household is a sugarcane grower and is zero otherwise. Other variables range from household institutional and locational factors such as age of household head, gender of household head, marital status of household head, education of household head and spouse, household size, farm size, access to extension services, access to markets, wealth status, crop diversification, allocation of crop harvest proceeds,

Figure 1: Conceptual framework on pathways through which sugarcane growing affect food security



Source: Authors won conceptualisation, 2023

household non-farm income (wages and salaries) among others (Figure 1).

There are two pathways through which sugarcane growing contributes to household food security. First, sugarcane growing households may decide to allocate their land to sugarcane production to obtain cash income. The household income generated through sale of cane to the market can be used to purchase food items. It is that proportion of household income from cane sales spent on food that enhances household food security status. Second, if the income is not adequate to meet food obligations as the case has been when farmers failed to sell cane for years, households may decide to reduce food expenses to maintain a certain standard of food status in a household. In the long run, if there is a decline in income from cane which could be due to a reduction in prices at which cane is sold or a complete failure by millers to buy the farmers cane, then sugarcane food intake may be impaired.

3.4 Poisson Regression Model

In analysing the effect of sugarcane production on household food security, the study used a Poisson regression model specification given that the three food security outcome variables used are count variables. The model estimates the impact of these predictors on the expected count or rate of the event of interest. The Poisson regression model assumes equi-dispersion - that the mean and variance of the count variable are equal. However, if this assumption is violated and overdispersion occurs, Poisson estimates can be biased, though alternative models like the negative binomial regression can be used.

Poisson Regression Model

The Poisson regression model is a generalised linear model (GLM) that meets the classical assumptions with only one exception, the distribution. The dependent variable assumes the Poisson distribution; regardless of whether the distribution is maintained or not, asymptotically normal, and consistent estimators of B_k are obtained.

The GLM is written as:

$$g\left[E\left(y|x_1,x_2,...,x_k\right)\right]=\beta_0+\beta^T x_k; y|x_k \square D(\theta), \quad (1a)$$

Where β_0 is the intersection term, β is a vector of coefficients, $g(.)$ is a link function, and $D(\theta)$ is a distribution in the exponential family with one parameter θ. The Poisson regression model assumes a Poisson distribution $P(\theta)$ under an error structure and a logarithmic function as the linkage function.

The Poisson distribution has the property of robustness and is wholly determined by its average $E\left(y|x_k\right)$. This distribution, which is the basis of the Poisson regression model, allows us to find conditional probabilities for any value of the explanatory variables. The Poisson regression model is expressed as follows:

$$\log\left[E\left(y|x_1,x_2,...,x_k\right)\right]=\beta_0+\beta_1x_1+...+\beta_kx_k;$$
$$y|x_k \square P(\theta) \quad (2a)$$

In particular, the expected value is expressed as an exponential function (equation 2a), and the mean is equal to the variance (equation 3):

$$E\left(y|x_1,x_2,...,x_k\right)=\exp\left(\beta_0+\beta_1x_1+...+\beta_kx_k\right) \quad (3a)$$
$$\mu=E\left(y|x_k\right)=Var\left(y|x_k\right)=\exp\left(\beta_0+\beta^T x\right) \quad (4a)$$

The probability density function (pdf) of the Poisson distribution is given by:

$$f(y)=\frac{\mu^h e^{-\mu}}{h!},\ h=0,1,2,..., \quad (5a)$$

Where $f(y)$ is the probability that the variable y takes non-negative integer values $(0,1,2,...,n)$ and $h!$ denotes a factorial. The dependent variable is a discrete-count variable that takes non-negative integer values. Therefore, a Poisson regression model is more appropriate than a linear regression model.

The empirical application of the Poisson regression model is described in the following equation:

$$g(y)=\log\left[E\left(y|x_k\right)\right]=\beta_0+\beta_1x_1+\beta_2x_2+....+\beta_kx_k+u_i, \quad (6a)$$

Where y is the HFIAS/HDDS/MAHFP, a count dependent variable; β_0 is the intercept; $\beta_1,\beta_2,...,\beta_k$ are vectors of unknown parameters to be estimated; x_k is a vector of explanatory variables of household i; u_i is a robust standard error term. Explanatory variables include demographic, socioeconomic (household is cane grower or not), and social characteristics (household size, age, sex,

level of education of head and spouse, land area, marital status of head, access to market, annual household income among others). The maximum likelihood method (MLE) estimates the model parameter vector.

Put more simply, we estimate our Poisson model as below with variables as explained above with inclusion of a binary variable of whether a household is a cane grower or not as an explanatory variable.

$$y_i = \beta_0 + \beta_1 Canegrow_1 + \beta_i X_i + u_i, \quad (7a)$$

3.5 Ordinal/ordered Probit Model

Determinants of household food security among households in sugarcane sub regions are derived by employing an ordinal/ordered Probit, as one of the measures of food security is also derived as a categorical and ordinal. The multinomial probit or logit in this case would not be ideal as it does not account for the dependent variable's ordinal nature despite the outcome being discrete. The ordered probit is the most widely used in several studies for ordered response data and it assumes a normally distributed error term.

The ordered probit model, as formulated by (Greene, 2002) is modelled on an unobservable latent random variable as follows;

$$Y_i^* = x_i'\beta + e_i, \quad i = 1,2,...,N \quad (1b)$$

Where $E(e_i/x_i) = 0$ and $Var(e_i/x_i) = 1$. The observable variable, Y_i is treated as an ordinal variable with J number of response categories and as a representation of the theoretical random variable, y_i^*, and $\mu = \mu - 1$, $\mu_0 \mu_1 ... \mu_J - 1$ where μ_J defined as a vector of unobservable threshold parameters, with the relation between the observable and the latent variable expressed as;

$$Y_i = j \text{ if } \mu_j - 1 < y_i^* \le \mu_j, \quad j = 0,1,2,.....,J \quad (2b)$$

Where $\mu - 1 = -\infty$, $\mu = 0, \mu_j = \infty$ and $\mu - 1 < \mu_0 < \mu_1 < ... < \mu_J$. The probability can be written as:

$$\Pr ob[Y_i = j] = \Pr ob\left[\mu_{j-1} < y_i^* \le \mu_j\right]$$

$$= \Pr ob\left[\mu_{j-1} - x_i'\beta < e_i \le \mu_j - x_i'\beta\right]$$

$$= \Phi(\mu_j - x_i'\beta) - \Phi(\mu_{j-1} - x_i'\beta) \quad (3b)$$

Where J is the categories of responses to food security and $\Phi(.)$ is the standard normal cumulative distribution function.

$$\frac{\partial \Pr ob[Cellj]}{\partial x_i}\left[\phi(\mu_{j-1} - x_i'\beta) - \phi(\mu_j - x_i'\beta)\right]\beta \quad (4b)$$

Where $\phi(.)$ is the standard normal density function. Therefore, the empirical model for the analysis of this objective is specified as follows:

$$FS_{ij} = \alpha + \beta W_i + \delta Z_i + \varepsilon_i \quad (5b)$$

$$FS_{ij} = \alpha + \varphi Canegrow_i + \beta W_i + \delta Z_i + \varepsilon_i \quad (6b)$$

The dependent variable, given as FS is the household's food security status proxied by HFIAS. i characterises the ith household, $j(j = 0,1,2,3)$ represents the four categories of the dependent variable indicated as; if household falls within severely food insecure, moderately food insecure, mildly food insecure or food secure categories for HFIAS, $\alpha, \beta, \gamma, \delta$ are estimated parameters; W and Z are socioeconomic characteristics, and institutional and location characteristics of the respective household expected to influence their food security status.

Following Hyodo and Hasegawa (2021), the Chi-square test was used to analyse whether food security status of households was affected by some independent variables of the study. This was to test the general null hypothesis that food security status of households is independent of the categorical variables of interest. The general alternative hypothesis states that food security status of households is not independent of the categorical variable of interest. This checks the robustness of the ordered probit model used in the study. The Chi-square statistics are calculated as below:

$$\chi^2 = \sum_k^r \sum_j^c \frac{(O_{kj} - E_{kj})^2}{E_{kj}} \text{ and } E_{kj} = \frac{R_k C_j}{n} \quad (6b)$$

where χ^2 -Chi-square; k -independent variable classification; r - total number of classifications for each independent variable; c - total number of food security status categories; j - food security status categories $j = 0,1,2,3$

O_{jk} - observed number of households for each classification and food security status categories
E_{jk} - expected numbers of households for each classification and food security categories
R_k - sum of households for all food security status in the classification k
C_j - sum of households for all classifications for food security status j
η - total number of households

To analyse if the differences in institutional arrangements between millers and growers lead to differences in the household food security of cane producers, we use Poisson regression and control for only cane growers and introduce miller-outgrower arrangements as one of the explanatory variables. We modify equation 7a and include out-grower models and estimate equation 1 c.

$$y_i = \alpha + \beta AidModel_i + \theta Z_i + \upsilon X_i + u_i, \text{ if cane grow} = 1 \quad (1c)$$

Where y are the various measures of food security.

Lastly, the study also set out to answer the question of whether women's influence in intra-household decision-making in crop choice, crop marketing, and allocation of crop sales income influences household food security. To answer this, the survey was designed to gather gender-differentiated information on land ownership and decision making at the plot level, for all plots. For example, for each plot, the survey asked three gender-related questions, including: (i), "who makes the final decision on what to plant on the parcel?"; (ii)who decides whether to sell or consume output from this plot?" and (iii) 'Who decides how to allocate income from crop sales from this parcel?" The ownership, allocation and decision makers considered were Male head, other male household member, Female head/Spouse, other female household member, jointly between male head and Spouse, and others (Specify). Collating all plots owned by an individual within a household, we construct a decision-making variable at plot level first which we collapse to household level.

$$y_i = \alpha + \phi decision_i + \theta Z_i + \upsilon X_i + u_i, \quad (1d)$$

Where ϕ are dummy variables of male head, female head/spouse, jointly husband and spouse, and other members and mixed (combines other male household member, other female household member, and others (specify)).

3.6 Sensitivity and robustness checks

Different impact estimation procedures may lead to slightly different impact estimates, especially when cross-sectional data is used for impact assessment. Because this study uses cross-sectional data, sensitivity analysis of our impact estimates was conducted using a propensity score matching (PSM) approach, using different matching techniques (nearest neighbour, and Kernel regression). Additional matching techniques such as the nearest neighbour matching (NNMatch), inverse probability weighting (IPW) was also used for robustness. In the absence of randomized treatment of an intervention or program, estimating the impact of program participation (or treatment) can be difficult, as factors typically unobserved within household surveys – such as cultural norms, religious beliefs, and other unmeasured explanatory variables -- may simultaneously affect participation in the program and the outcome. In this case, sugarcane production may be correlated with unobserved household-specific factors also correlated with household food security. Due to a lack of a suitable instrumental variable, the following analysis proceeds on the assumption that a dummy variable indicator of household participation in cane production is exogenous within our regression models. This assumption does not appear to be strong given the range of household and community-level controls in our regression models that are known to influence a farmer's decision to grow cane or not – such as their total landholding and total asset value -- as well as their household food security status during the recall period.

4. RESULTS AND ANALYSIS

In this section, first we examine the social-economic characteristics of the sampled cane and non-cane growing households, the institutional and community characteristics of the villages, and food security status of cane and non-cane growing households. Consequently, we then, dwell on analysing the relationship between the various food security indicators and sugarcane growing. In addition, using our conceptual framework, we present econometric results of the Poisson and ordered Probit estimates for various

specifications of food security along the key questions and hypotheses to be tested.

4.1 Social-economic and institutional characteristics

From Table 2, the average age of household head was 48 years. About 9 out of 10 households among cane growers were male headed compared to 7 out of 10 among non-cane growers. The average family size of a household is about 5 persons with an average number of 4 children per household with significant mean differences between cane and non-cane growers. About 46% and 49% of the cane and non-cane grower households' heads were employed for salary or wage. Cane-grower households had more land almost 7-folds more than the non-cane growers. Cane grower households are more educated and literate. More so, adult females (18 years+) max education was higher among cane growers 8.3 years while for non-cane growers had 7.02 years. Regarding household wealth, there were significant difference in household value of asset and ownership of medium livestock units in favour of cane-grower households. Simply put, cane growers' value of household assets is over three time more than that of non-cane growers (Ugx3.3m vs Ugx0.92 million respectively). Among cane growers, decisions on how to allocate crop production harvested such as sell or consume is done mainly by the male head (49%) with less decisions made by the female spouse or jointly done. Similarly, non-cane grower household had 40.0% of decisions on allocation of income from all crop harvest undertaken by male heads respectively, with no significant differences in allocation decisions undertaken by female heads/spouses. Simply put, patriarchy is more entrenched in cane-growers' households.

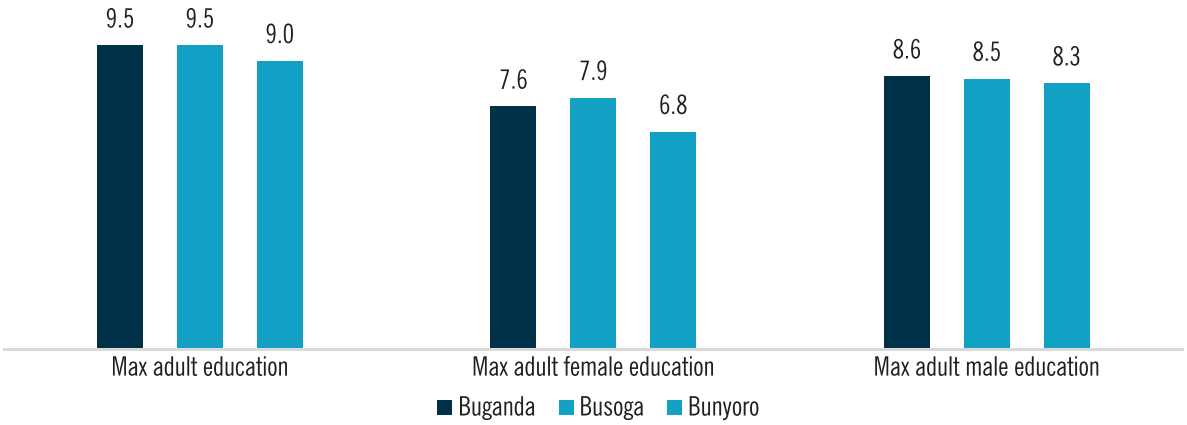
Table 2: Socioeconomic characteristics

Select indicators	All	Cane Producers	Non-Cane Producers	Diff (p-value)
	(1)	(2)	(3)	(4)
Age of household head (yrs)	48.23	48.63	47.96	0.244
Sex of head (1 if male)	0.79	0.86	0.75	0.048
Household adult equivalence	4.99	5.40	4.70	0.009
Head employment status (1 if employed)	0.48	0.46	0.49	0.232
Annual household non-agric income ('000 ugx)	1,045.14	1,111.22	999.87	0.468
HH total land size in acres	7.68	14.83	2.77	0.000
HH total sugarcane land in acres	6.89	7.42	1.98	0.000
Household composition				
# children <18 years	3.56	3.82	3.38	0.010
# female adults 18+ years	1.43	1.55	1.35	0.000
# male adults 18+ years	1.35	1.47	1.27	0.085
Education indicators				
Literacy of household head (1 if literate)	0.69	0.76	0.64	0.061
Max adult education level in the HH	8.98	9.68	8.49	0.000
Max adult female education level in the HH	7.55	8.30	7.02	0.000
Max adult male education level in the HH	8.56	8.90	8.30	0.007
Religion of household head				
Catholic	0.25	0.21	0.27	0.042
Anglican	0.39	0.40	0.38	0.643
Other Christian	0.10	0.09	0.10	0.682
Muslim	0.25	0.28	0.23	0.040
Others (specify)	0.01	0.01	0.00	0.253
Household wealth				
HH value of assets ('000 Ugx)	*1,887.8*	3,303.0	918.2	0.002
# of household assets	7.55	8.37	6.99	0.000
HH Total # Tropical Livestock Units	0.55	0.59	0.52	0.150
HH # large livestock	0.34	0.36	0.33	0.345

Select indicators	All	Cane Producers	Non-Cane Producers	Diff (p-value)
	(1)	(2)	(3)	(4)
HH # medium livestock	0.97	1.08	0.89	0.051
HH # small livestock	0.81	0.88	0.76	0.238
Household decision on allocation of income from crop harvest				
Male head	0.44	0.49	0.40	0.002
Female head/spouse	0.19	0.14	0.22	0.133
Jointly Husband and spouse	0.19	0.14	0.23	0.046
Others members and mixed allocation	0.19	0.23	0.16	0.001
N	1,771	983	788	
Notes: * Annual household income =Annual salary income + wage income				
* Off-farm employment=Salaried/wage earner/own business				

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Figure 2: Maximum years of household education attainment for adults 18+ years



Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Given the potential role of education in shaping household incomes and decision making on food security, sub regional insights on maximum adult education attainment show that Buganda and Busoga subregions have similar levels of maximum adult female education levels (7.7 years on average), while that of Bunyoro is a bit lower (6.8 years) (Figure 2). Likewise, maximum adult male education levels were higher on average in Buganda and Busoga than in Bunyoro.

Concerning institutional and community characteristics, Table 3 provides such insights. On average households grow about 3 food crops. About 24.9% and 19.4% of cane grower and non-cane grower households respectively received extension support for other crops grown. Access to market on average took 23 minutes to walk within 2 miles. Most households (over 70%) in our study are from Busoga subregion. There were no significant differences in distance to districts or food markets. Differences in household experiences to shocks are noted disease and pests, and income related shocks.

Table 3: Institutional and community characteristics

Indicator	All	Cane Producers	Non-Cane Producers	Mean diff (p-value)
	(1)	(2)	(3)	(4)
# of household food crops	3.38	3.35	3.40	0.668
Location-Sub-region of household				
Buganda	0.15	0.15	0.15	0.694
Busoga	0.74	0.71	0.76	0.144
Bunyoro	0.11	0.13	0.09	0.114
Access indicators				
Distance from house to mill (km)	22.96	23.51	19.64	0.162
Distance to district (miles)	11.03	10.78	11.21	0.722
Distance to market (miles)	2.17	2.54	1.92	0.146
Credit and extension indicators				
Hh extension support for cane production (1 if yes)	0.17	0.34	0.06	0.000
Hh extension support for crop production (1 if yes)	0.22	0.27	0.19	0.000
Household shocks experiences				
Experienced at least one shock	0.94	0.92	0.95	0.051
Natural calamities (floods, droughts, landslides, hailstorm)	0.56	0.53	0.57	0.129
Diseases and pests	0.31	0.34	0.29	0.06
Income related	0.35	0.32	0.37	0.074
Death	0.05	0.06	0.04	0.123
Other shocks	0.25	0.29	0.21	0.002
N	1,771	983	788	

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

4.2 Food security status overview

The mean values for HDDS and MAHFP were higher in cane grower households than for non-cane growers while the mean HFIAS score was higher in non-canegrower households (Table 4). That is the HDDS mean score for cane and non-cane growers is 6.6 and 5.97 respectively with the same median score of 6, on a scale of 0 to 12 food groups. The MAHFP shows that cane grower households had on average 10.3months of adequate food while non-cane grower households had 9.1 months of adequate food provisions. For HFIAS score, the lower the score (0-27) the less food insecure is a household, implying that a HFIAS score of 6.14 and 7.84 for cane and non-cane grower households implies that the latter households' access to food is burdensome. Using the HFIAS scale, about 27% of the sampled cane grower households were food secure. In the same category, sampled households who were mildly, moderately, and severely food insecure represented about 9%, 43% and 21% respectively as measured by HFIAS scale. In sampled non-cane grower households, 24% were food secure while 10%, 36% and 30% were mildly, moderately, and severely food insecure respectively. Non-cane growers were the majority in the moderately and severely food insecure categories compared to cane growers. Generally, using the HFIAS scale, 4 out of 10 households are moderately food insecure irrespective of cane growing status. Significant differences are observed in all food security indicators between cane and non-cane grower households. Clearly food insecurity (using the three measures) is still a major challenge faced by majority of households in Uganda and more especially among non-cane growers.

The descriptive analysis above has compared household food security and household characteristics between households that currently grow cane (2021) and those that do not and finds that cane growers have higher food security measures (on average) compared with non-growers. However, if cane production "causes" food insecurity, on average, then the mean of average food security of non-cane growers could potentially be pulled down (perhaps below that of current cane growers) due to low food security levels of past cane growers that have not yet recovered from financial

Table 4: Summary statistics of food security indicators by cane status, December 2020-November 2021

Select indicators	All	Cane Producers	Non-Cane Producers	Mean diff (p-value)
	(1)	(2)	(3)	(4)
Household diversity score (HDDS)	6.22	6.60	5.97	0.022
Month of adequate household food provision (MAHFP)	9.59	10.31	9.10	0.000
Household food insecurity score (HFIAS)	7.15	6.14	7.84	0.000
Household food insecurity scale (HFIAS)				
Food secure	0.25	0.27	0.24	0.451
Mildly food insecure	0.10	0.09	0.10	0.734
Moderately food insecure	0.39	0.43	0.36	0.384
Severely food insecure	0.26	0.21	0.30	0.000
N	1,771	983	788	

Note: The non cane grower households (column 3) combine past-cane growers and never grown cane households.

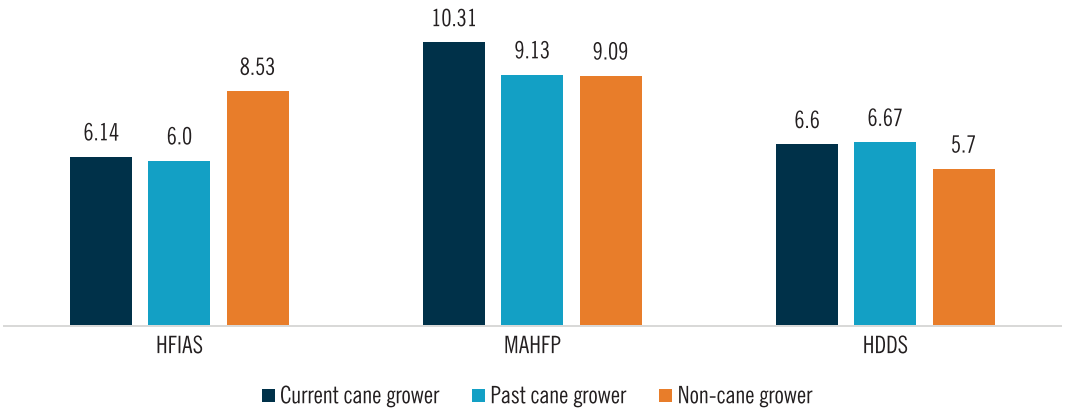
Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

losses in a prior year related to cane production. Ideally, if observations of food security and cane participation for the sample households had been observed in both 2021 and a prior year, it would theoretically have been possible to test whether there is any causal effect of cane participation on household food security using a difference-in-differences approach. Because this study has only cross-sectional data 2021 to use, a different approach is needed.

We thus divide the subgroup of households that do not currently grow cane into those that are past cane growers and those that have never grown cane. Interestingly, past cane growers have better or similar food security measures than those that have never grown cane (Figure 3). This does not imply that some past cane growers are not food insecure and that that status may be due in part to financial losses from cane production in a prior year. However, it does show that the subsample of farmers that have never grown cane have lower food security measures than both current and past cane growers, on average.

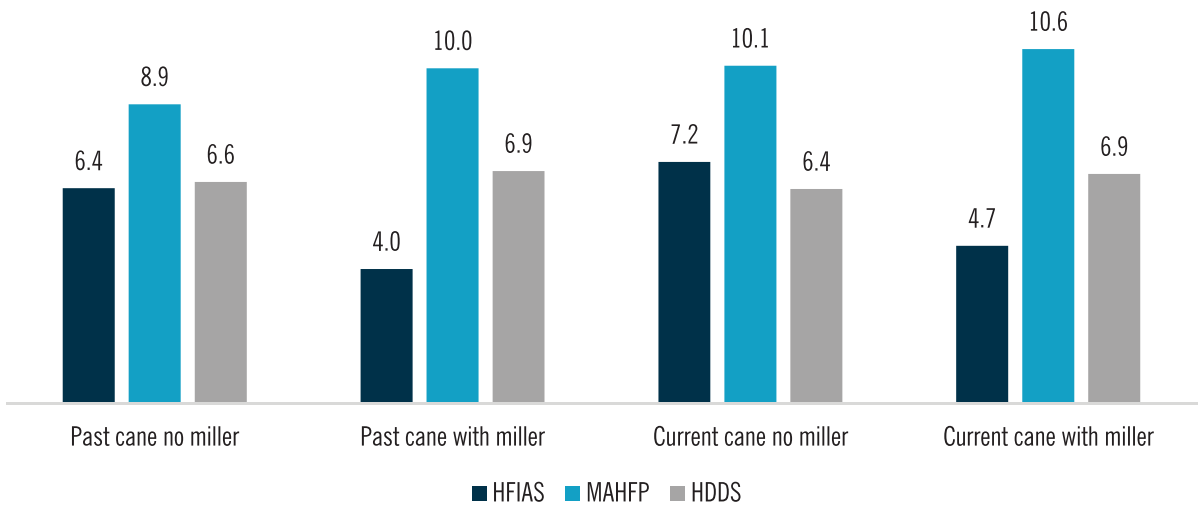
Next, the subgroups of current cane growers and past cane growers are divided into two subgroups based on their current (or past) registration status with a mill. For example, if a current grower is registered (contracted to deliver cane to a mill) or registered with aid (registered and provided some inputs by the mill, possibly on credit), they are termed "current cane with miller" in Figure 4. Current cane growers that are not currently registered or registered with aid are classified as being "without a miller. This can also be done with past cane growers, where there is "with" or "without "miller status refers to their relationship (or not) with a mill in the last year that they grew cane.

Figure 3: Household food security measures status by cane growing status



Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Figure 4: Food security measures by cane grower status miller relationship



Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

We find that both current and past cane grower households who have (had) arrangements with a mill in 2021 (or in last year they grew cane) have better food security levels for HFIAS (i.e., lower value) and MAFHP and HDDS (higher value) than both households that have never grown cane and past cane growers who did not have arrangements with a mill. It is not clear whether causality runs from inherent grower characteristics that enable them to achieve higher income and food security, if becoming registered or registered with aid with a mill causes better food security outcomes, or if some of both occur.

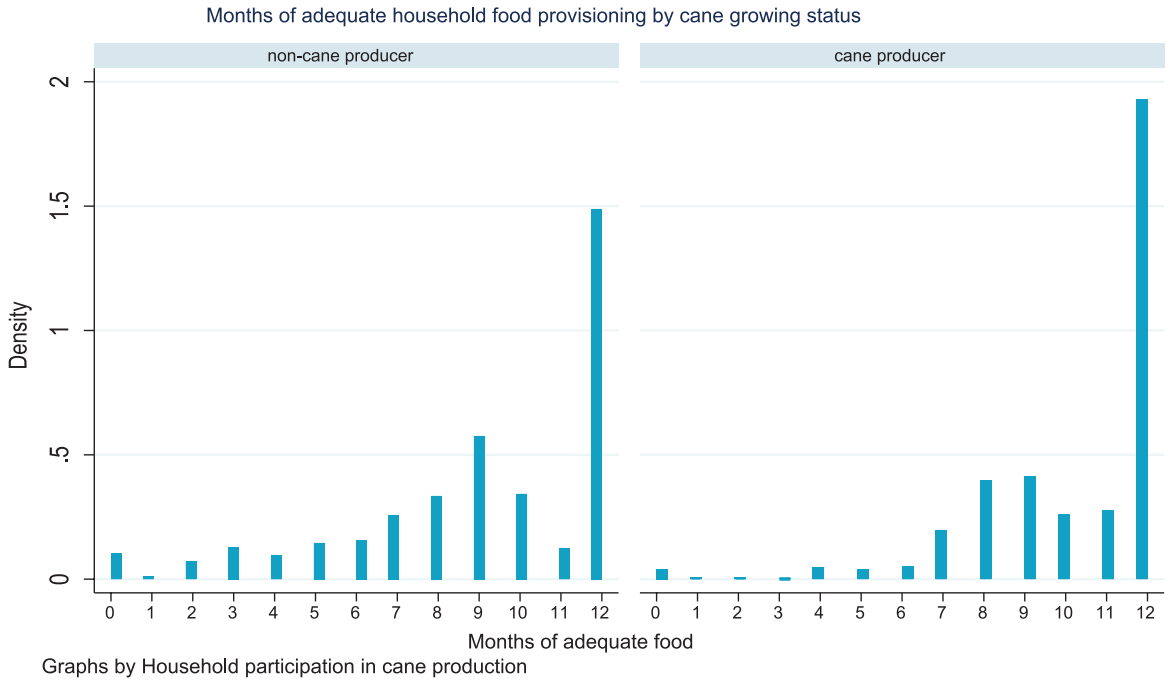
4.2.2 Does food security differ by cane growing status?

More cane growing households indicated in December 2021 that they had had adequate food provision over the prior 12 months as compared with non-cane households. In addition, a histogram of MAHFP, which shows the density of this variable, shows visually that current cane growers are more likely to have higher number of months of adequate food provision compared with non-growers in 2021 (Figure 5).

Figure 6 further shows that about 24% of the sampled households reported February, March, and January of 2021 as the months in which they had inadequacy in food provisioning. These months correspond with the second season cropping period when Uganda's climate variations often result in droughts that in turn can result in food price spikes as food supplies dwindle. The seasonality of food prices and availability highlight the need for households to have enough income and/or savings to ensure access to food even during the months each year with the most limited food supplies and highest food prices.

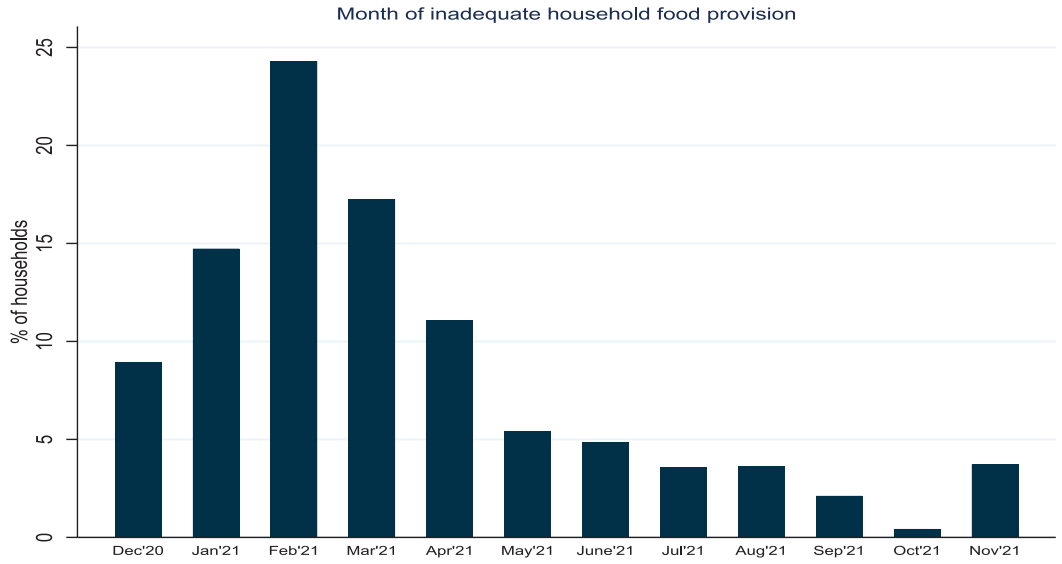
Figure 7 shows that while February 2021 was the commonly cited month of inadequate household food provisions irrespective of cane status, for the other months inadequacy differed among cane and non-cane growers. While among non-cane growers, seasonality in cropping periods partly explained the food inadequacies in the various months with a clear patten, among cane growing households, the pattern beyond seasons was partly driven by sales of harvest to mills and payment for sugarcane harvests. At the time of the survey, at least a good portion of households had sold cane around August to October 2021 and income from cane had started to dwindle hence observed increase in inadequate food provisions in November as cane markets were sticky. The takeaway is that the non-cane growers reported a relatively widened spell of more months of limited food provisions than cane growers.

Figure 5: Months of adequate household food provisioning (MAHFP) by cane grower status



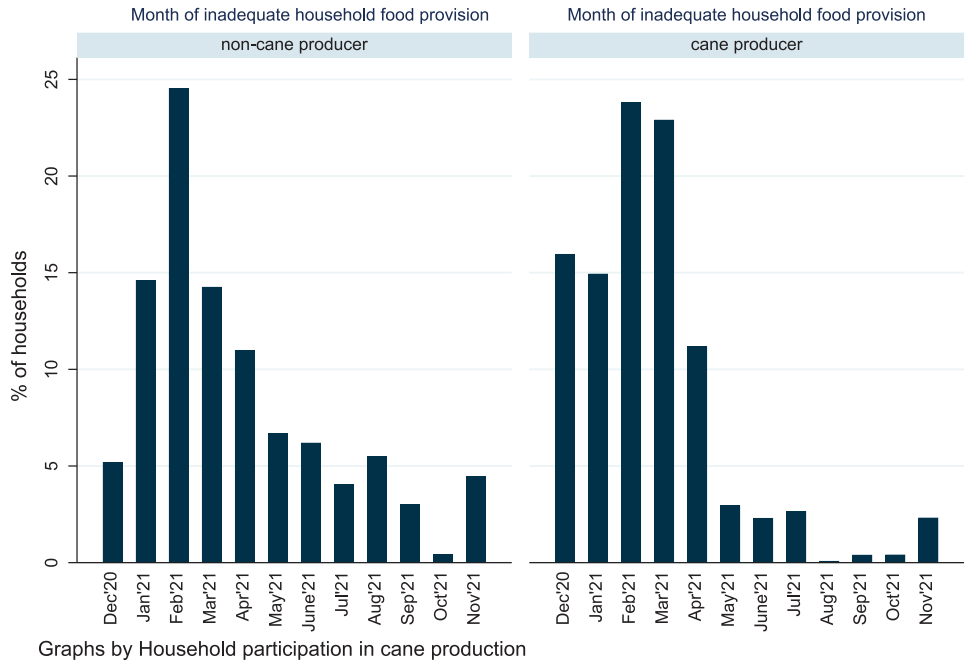
Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Figure 6: Share of households with inadequate household food provision, by month, 2021



Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

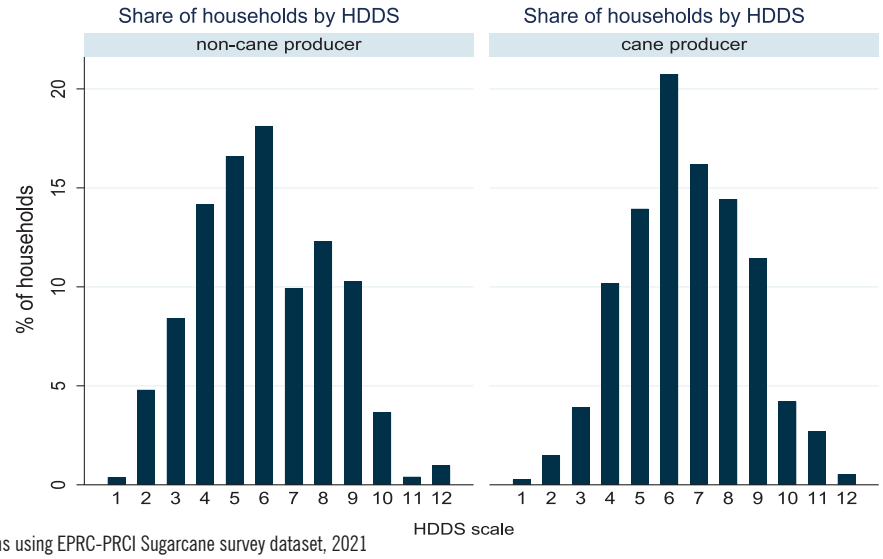
Figure 7: Months of inadequate household food provisions among households by cane grower status (%)



Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Appendix Table 1 provides the details of the food groups consumed as categorised in the survey questionnaire following Swindle and Bilinsky (2006). Using the household dietary diversity score (HDDS), Figure 8 illustrates the distribution share of households by consumption of food groups by cane grower status. The distribution of the HDDS is more symmetric in profile especially for cane growers. This indicates that HDDS of cane growers is concentrated among slightly higher values of HDDS compared with non-growers, which helps to explain why mean HDDS is higher for growers than non-growers. That is in the sugarcane sub regions about 17.8% of non-cane and 21.1% of cane producer households consume at least six food groups. Appendix Table 2 highlights the distribution of HDDS by gender of head and cane growing status. Female headed consumption patterns mimic non-cane producer households while male headed households' food consumption groups are like cane-producer households.

Figure 8: Share of households by HDDS and cane growing status, 2021

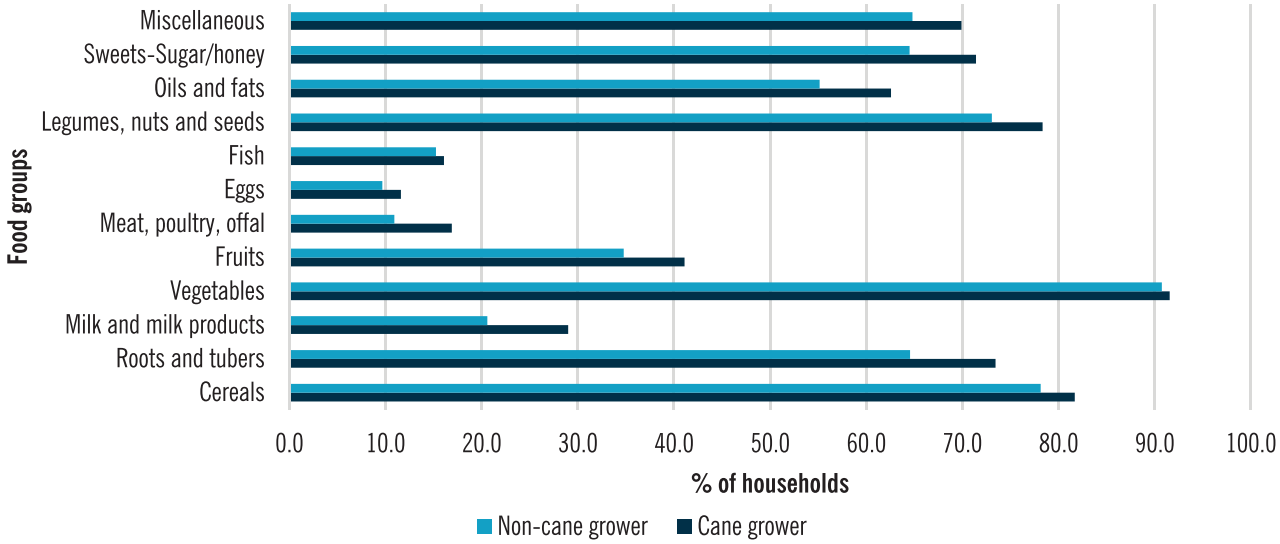


Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

For all the food groups, cane grower household consumed more shares especially foods with high protein content compared to the non-cane growers. The food groups most consumed among cane producer households are Meat, poultry, offal; eggs and fish. More than 8 in 10 cane grower households consumed meat, poultry, offals. Among non-cane producer households, Meat, poultry, offal; Fruits and vegetables are the most consumed (Figure 9). More specifically, by gender of head, the patterns of food groups consumed was the same, but significant differences in shares consumed were on protein related food groups, such as meat, poultry, offal, eggs, fish, milk and milk products and sweets-sugar/honey (Figure 10).

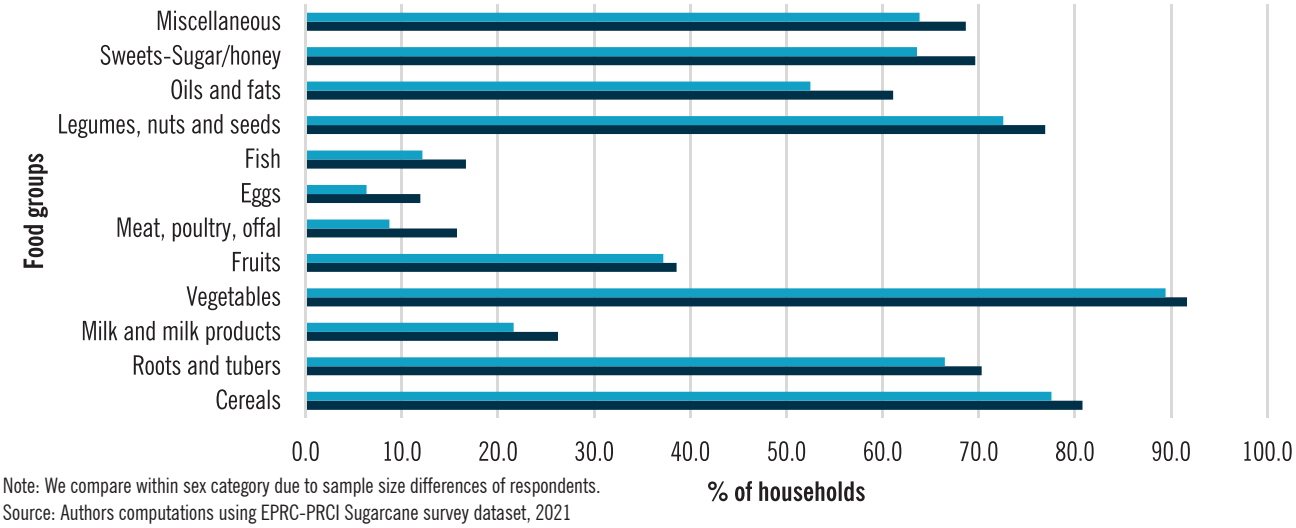
The HFIAS scores in Figure 11 show the distribution of HFIAS among cane growers and non-growers across the variable's range from 0-27. The higher the score the more food insecure a household is with respect to accessing its required food needs. The large density around zero indicates a significant share of farmers that indicated having no aspects of household food insecurity within the past week.

Figure 9: Share of households consuming different food types by cane growing status, 2021



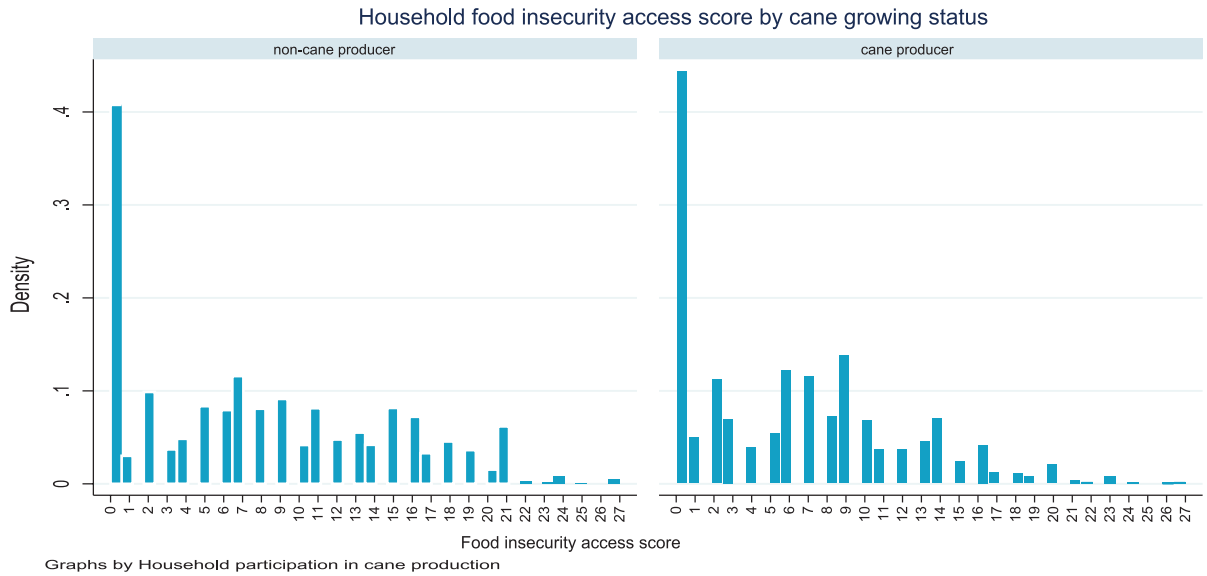
Source: EPRC-PRCI Sugarcane survey dataset, 2021.

Figure 10: Percentage distribution of last 24 hours households food groups consumption by gender of head, 2021



Note: We compare within sex category due to sample size differences of respondents.
Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Figure 11: Household food insecurity access score by cane growing status



Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Figure 12: Share of household reporting food insecurity by scale and cane growing status

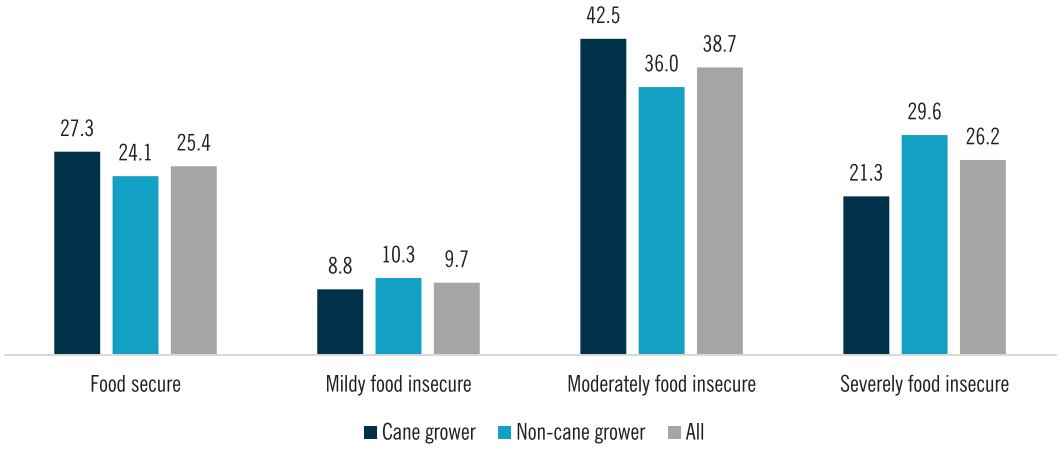


Figure 12 shows the depth of food insecurity using the HFIAS measurement. The findings show that one in every four households in the sugarcane growing subregions are food secure. About 27 out of every 100 cane growing households while 24 out of 100 non-cane households were food secure. Generally, food security is of a major concern in subregion where in 2021, 75 out of 100 households were food insecure but at varying levels. That is, non-cane growers were significantly more food insecure than cane grower households (Mildly food insecure and severely food insecurity scale categories) while cane grower households had majority who were moderately food insecure (42.5%)

Table 5 further illustrates the household food security status by cane grower arrangements. Findings emphasise the need for market assurance for food security. Households that were growing cane as of 2021 with clear miller arrangements and those who stopped growing cane but had arrangements with a miller had better food security share (37.2% and 50.8% respectively) compared to those currently and those in the past have no miller arrangements. In other words, food insecurity increased with no market assurance (Table 5). Household food security also varies by gender of the head, as those with female heads are more likely to be severely food insecure (39%) than those with male heads (23%) (Appendix Table A2). Yet, female headed cane growing households are less likely to be severely food insecure

Table 5: Household food insecurity access scale by cane-miller arrangements, %

Food security scale	Past cane no miller	Past cane with miller	Current cane no miller	Current cane with miller	Total
Food secure	27.8	50.8	20.0	37.2	25.4
Mildly food insecure	19.4	8.6	6.5	11.9	9.7
Moderately food insecure	32.8	32.3	45.6	38.5	38.7
Severely food insecure	20.1	8.3	27.9	12.5	26.2
Total	100	100	100	100	100

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Table 6: Food security status by household average land holdings in acres and cane growing status

	All			Current cane grower		Past-cane grower		Non cane grower	
HFIAS-scale	Mean	Median		Mean	Median	Mean	Median	Mean	Median
Food secure	12.78	3.60		25.69	9.50	2.72	1.55	2.79	2.00
Mildly food insecure	7.84	5.00		15.41	10.00	3.37	2.50	3.46	1.50
Moderately food secure	6.93	4.00		11.25	6.57	4.66	5.00	3.05	2.00
Severely food insecure	3.78	1.75		7.93	5.00	2.77	1.25	1.52	1.12
Total	7.68	3.00		14.84	6.57	3.48	2.00	2.51	1.75

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

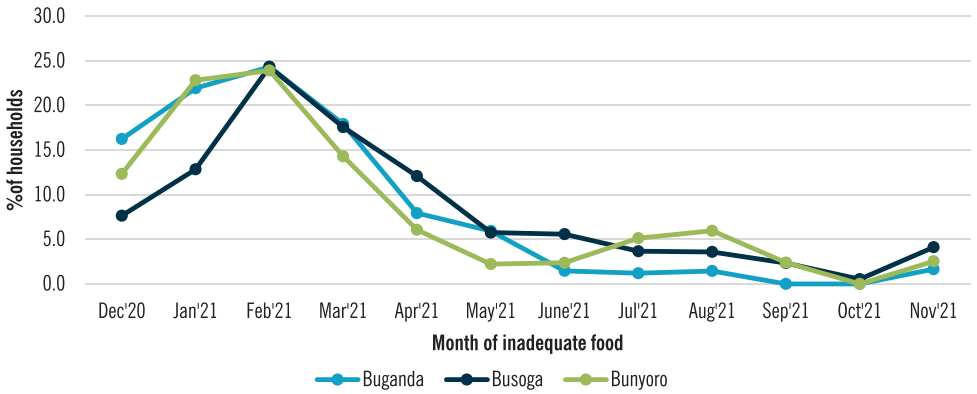
(33%) compared with female headed non-grower household (41%). A similar pattern is seen for male headed cane and non-cane growing households.

Households with less land were likely to be severely food insecure irrespective of whether they grow, ever grown or never grew cane (Table 6). Non-cane growers are land constrained. Nonetheless, land utilisation also matters for food security. Non-cane growers with smaller acreage were food secure due to proper utilization. As long as the status quo remains, even with land size above 15 acres, food insecurity will remain a challenge in cane grower households. Even with households not growing cane, food insecurity will loom unless intensification of food production is emphasised.

4.2.2 Sub regional heterogenity in food security by cane growing status

On average, February is the month in which the highest share of households (24% across the 3 regions) reporting that they had inadequate food provision. The share of household with inadequate quantities of food rises considerably from November to February, then begins to decline in March as farm households being to harvest food from their major season, then falls to a share of only 5% of households from June until November (Figure 13). The trend corresponds to Uganda's climatologies and the bimodal cropping seasons (major season is in March–May and a shorter rainfall season in September–November).

Figure 13: Percentage of households by month of inadequate household food provision, %



Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Table 7: Household dietary diversity Score by subregion and cane grower status, %

	Buganda				Busoga				Bunyoro			
HDDS	Current cane	Past cane	Non-cane	Total	Current cane	Past cane	Non-cane	Total	Current cane	Past cane	Non-cane	Total
1	1.1	0.0	1.8	1.4	0.1	0.1	0.2	0.2				
2	1.8	0.0	5.8	3.8	1.3	1.0	5.5	3.0	2.3	0.0	11.6	6.4
3	8.8	3.6	9.8	9.1	1.6	8.8	7.1	5.3	10.5	0.8	14.8	12.0
4	7.6	6.2	8.1	7.8	9.6	4.1	20.4	12.9	16.3	9.2	17.3	16.4
5	10.4	24.1	15.3	13.7	14.1	18.1	15.8	15.6	17.2	28.1	16.4	17.4
6	16.9	21.2	16.6	16.9	22.1	11.4	22.1	20.0	17.8	11.1	16.7	17.0
7	16.3	8.4	10.6	12.9	16.5	14.2	7.1	12.2	14.7	24.7	12.0	13.9
8	16.1	22.3	12.7	14.6	14.9	24.1	6.7	13.4	9.7	18.8	8.3	9.5
9	12.3	11.5	9.4	10.7	12.6	14.8	9.8	11.9	4.2	3.3	1.7	3.0
10	4.8	0.8	6.0	5.2	4.0	0.6	5.0	3.7	4.6	3.9	1.4	3.1
11	2.1	0.0	2.3	2.1	3.0	0.0	0.2	1.3	1.8	0.0	0.0	0.9
12	1.9	1.9	1.8	1.8	0.2	2.8	0.0	0.6	1.0	0.0	0.0	0.5

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Within the subregions by cane growing status, there were differences in the dietary diversity of the households. From Table 7- in Buganda and Busoga subregions, most households were consuming at least six food groups irrespective of cane growing status. Interesting insights show that majority of past cane growers in Buganda had diversit of at aleast five food groups while those in Busoga had to about eight food groups in their diet. In Bunyoro sub-region the HDDS was varying as current cane growers had a higher diversity compared to past or non cane growers. The later category had the lowest HDDS of four food groups in their diet.

Farm households in Buganda are more likely to be food secure (41%) than those in Busoga (23.8%) or Bunyoro (15%) (Table 8). In each region, cane growers are more likely to be food secure (and les slikely to be severely food insecure) that non-cane growers. The most significant regional difference in food security in 2021 is that moderate and severe food insecurity is much more common in Busoga and Bunyoro than in Buganda. For example, about 68% of households in Busoga were moderately or severely food insecure compared with 65% in Bunyoro yet only 44% in Buganda. This is likely due to the fact that Bugandan households have considerably more asset wealth than the other regions. In fact, median Bugandan total household value of assets per adult equivalent (AE) – including livestock, household, transport assets - was 518,000 Ush/AE, which is nearly double that of Bunyoro (234,000 Ush/AE) and Busoga (288,000 Ush/AE). This is likely explained by the fact that households in Buganda have access to more remunerative activities in both crop production (coffee and banana, in addition to cane) and nonfarm own business and employment – given their proximity to Kampala. Part of the relatively high food insecurity in Bunyoro observed may be related to the fact that the 2 large mills in Bunyoro harvest farmers' cane for them, but then often do not pay the farmers for up to 2 months.

Table 8: Household food insecurity access scale by cane growing status and subregion, %

HFIAS scale	Current cane grower	Past cane grower	Non-cane grower	Total
All				
Food secure	27.3	31.9	21.1	25.4
Mildly food insecure	8.8	17.5	7.7	9.7
Moderately food insecure	42.5	32.7	37.3	38.7
Severely food insecure	21.3	18.0	33.9	26.2

HFIAS scale	Current cane grower	Past cane grower	Non-cane grower	Total
Buganda subregion				
Food secure	50.4	37.4	33.9	41.0
Mildly food insecure	15.3	6.7	15.9	15.2
Moderately food insecure	24.4	51.5	29.8	28.6
Severely food insecure	10.0	4.4	20.4	15.2
Busoga subregion				
Food secure	24.3	31.7	19.4	23.8
Mildly food insecure	6.5	18.6	5.2	8.4
Moderately food insecure	43.8	31.3	37.0	38.5
Severely food insecure	25.5	18.5	38.4	29.4
Bunyoro subregion				
Food secure	17.2	28.1	11.2	15.0
Mildly food insecure	13.8	1.4	10.3	11.6
Moderately food insecure	56.8	46.3	51.1	53.7
Severely food insecure	12.2	24.3	27.4	19.7
Total	100	100	100	100

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Box 1 highlights stakeholers views on the status of sugarcne growing and food secueiry in Bunyoro subregion, Masindi district in particular.

Box 1: Highlights from community baraza held in Masindi District, Bunyoro Subregion

Majority of the people were facing food uncertainties in Masindi sugarcane growing communities. This is because many people have taken on cane growing as a buffer for earning money. This means they left little or no land at all for food crops. A participant said: *"We have an issue of food security since most of the land is being utilised for cane growing. I started with one hectare and educated my children but as per now, Kinyara has taken long to harvest my cane and some is drying in the field."*

Another perspective was that those who are growing cane and have no food insecurity issues are the rich. A participant said:

"When you look at people involved in cane growing, these are people who are well-off. Almost 75% of the farmers are hiring land from the poor land owners."

Even those not growing cane are facing challenges because they hire out their land to outsiders to grow cane on them. This means their land is locked out for longer periods leaving them with no room to grow food on their own. Participants added that:

"A poor landowner has rented out land for a period of 6 years to an investor and remains with a very small portion for growing crops but that land is held for 10 years not the 6years agreed upon. The harvest is agreed upon for 18 months but it might go to 34 months which you have to multiply by four harvests. This is affecting landlords since your land is being held for a long period of time than anticipated and he doesn't pay you for the longer period but for only the harvest."

"You find a home surrounded by cane which does not belong to that household. We are also selling our own land once we get problems. Once done there is no food for the home. People are now cutting forest and digging in food reserves hence we have a problem of food. You find a woman waking up early in the morning to go and weed in Kinyara and a man gets a Panga to go and cut cane in order to get Posho, hence we have a serious food security problem."

It was also revealed that people new to sugarcane are dedicating all their land to cane without leaving some for other foods. A participant said: *"We farmers who started growing cane earlier have more knowledge than others and we don't have any food insecurity. Here for example, you cut your cassava and plant like 100 stems. These you will eat like for four months once harvested. How does a person complain of food security when he is s cane grower, I call that poor planning."*

Others said food insecurity was a much wider problem than people were willing to admit, and it goes beyond cane growing communities. A participant said that:

"There is no food completely when you go deep down in the villages and that is poor planning. Even outside cane growing area like in Kampala, we have people who feed on beans and posho from Monday to Monday. Food security here is hard, I used to feed my family on fish twice in a week and I cannot access fish because the government interfered and can now only afford small fish".

Another participant emphasised that: *"People do not follow advice. You are supposed to leave some land for food but they don't. The population has increased and the land acreage for sugarcane growing has increased and as it increases, the land acreage of food crops is reducing. Some 80% of the land being used for cane growing is managed by external people and a few people who come from within and the few rich people who own these farms. Some tenants who came from West Nile went back to West Nile hence migrating to their homes."*

Source: Community Baraza held in Masindi District on "Sugarcane production Vs Food Security: Is there cause for worry", December, 2021

4.2.3 Household wealth status for select indicators

Household wealth is expected to have a high positive correlation with household food security, as it provides the ability to achieve food security through the market purchase pathway. This strong positive correlation is apparent from shares of household by wealth quintile and by food insecurity access scale category. For example, among households categorized as food secure by the HFIAS measure, only 7% are from the lowest (first) asset wealth quintile compared with 33.7% in the top (fifth) quintile. Likewise, 42.6% of households categorized as severely food insecure are in the lowest quintile compared with only 6.8% of households in the top quintile. Shares of household distributed across the four food insecurity access scale categories computed by row show the same pattern, as only 9.7% of households in the first (lowest) wealth quintile are food secure compared with 55.8% that are several food insecure.

However, the vulnerability of rural Ugandans in these regions to various kinds of unexpected shocks (weather, insects, crop disease, illness, etc) appears to affect at least the temporary food security of even those in the top wealth quintile. For example, about 26% of households in the top wealth quintile reported moderate to severe food insecurity during the month prior to interview in Dec 2021.

The role of wealth in determing the food security of cane farmers was emphasised by participants as naratted below:

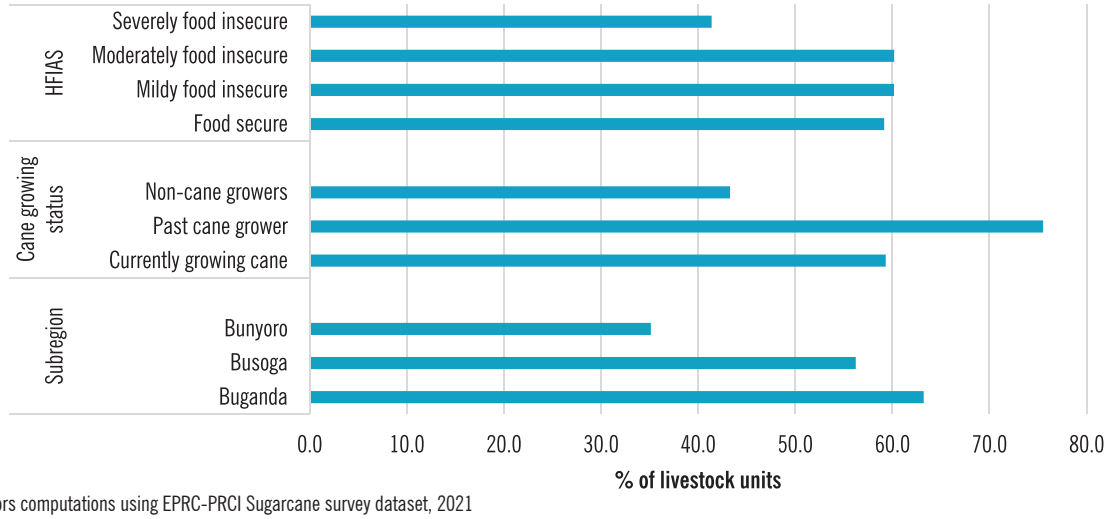
"…Sugarcane growing itself has no problem for farmers who have enough land. They have managed to grow sugarcane and utilize some land for growing food crops. The family doesn't lack food since you plant 3-4acres of food crops out of the 10 acres and the other 6 for sugarcane growing (by Male FGD participant Imanyiro Mayuge).

This was re-echoed by a female cane grower

"…People who have small pieces of land are growing sugarcane and they surely don't have food. Most people with limited land like two acres have used all the land for sugarcane growing, they even hired out most of their land to other people still to grow sugarcane and they abandoned food production. Me as a person, I left some land for different types of food like Beans, Cassava, Potatoes so me am very safe concerning food, but most people in my village don't have food (by Female FGD participant, Imanyiro Mayuge)

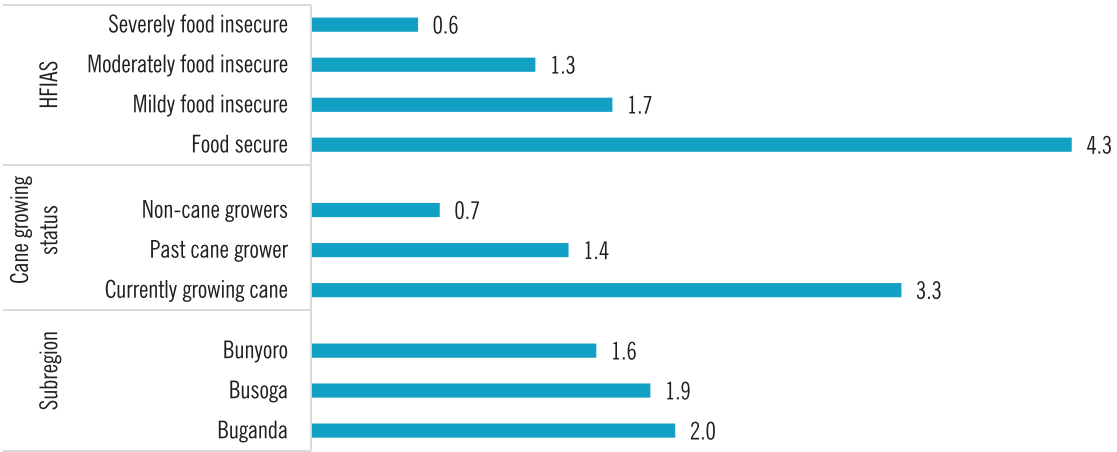
In looking at specific wealth idicators such as household ownership of livestok (Figure 14) and value of assets (Figure 15), by HFIAS, can growing status and subregion levels. For instance, we note that Buganda followed by and past cane growers and food seuecure and midley food insecure houdholds owenered a higher share of Itropical livestock than in Bunoro, non cane growing and severely foo insecure houeholdshad more live animals (Figure 14). Food secure, current cane growers and those in Buganda sub regions had household assets of much hgher value (Figure 15).

Figure 14: Household ownership of tropical livestock units by subregion, cane growing status and food securty status, %



Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Figure 15: Total household value of assets by subrgeion, cane growing status and food securty status, Ugx (million)



Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

4.3 Determinants of household food security in sugarcane growing regions

4.3.1 Poisson correlates of sugarcane growing effects on food security

Table 9 presents results of the Poisson regression model estimates for the effect of sugarcane growing on various food security outcome indicators of HFIAS, HDDS and MAHFP. Other explanatory variables are included to provide more precise effects of sugarcane growing on food security. Test of multicollinearity among variables was tested by first estimating an ordinary least squares (OLS) model and all variables with a very high VIF were excluded from the Poisson model specification such as marital status of the household head, others with VIF <14 such as total land size and household age were maintained in the model specification.

Furthermore, specification of the Poisson model was selected by econometric validity of the results obtained with the Negative Binomial regression model method. Application of the Poisson model was verified by the negative binomial model alpha of 0.971 with robust clustered standard errors of 0.1465 which indicates that the specification was not significantly different from zero. This implies that a Poisson

produced a better fit for the data.

The results highlight that: Table 9-Col (1) for HFIAS, household engaged in cane growing are expected to have 1.181 reduction in their food insecurity access scale and this was statistically significant $p<0.1$. Other factors such as being a male head, age of the household head, log of the annual income earned from a salary, maximum adult female education in a household ($p<0.05$), number of live large animals, household value of assets, and the number of food crops grown ($p<0.05$) all significantly reduced household food insecurity.

Besides, being in Busoga and Bunyoro sub regions in comparison to being in Buganda subregion ($p<0.05$), increased a household's food insecurity. In addition, households whose major source of earning was from a wage (known to be less stable), being in traditional religion in comparison to being a Catholic, shocks pertaining to crop pets and diseases and the distance to the district ($p<0.05$) are expected to have an additional increase on household food insecurity access and this is statistically significant. On interacting the binary cane production variable with select variables does not change the variables affecting HFIAS (Col. (2)).

Findings for HDDS food security measure (Table 9-Col (3)) reveal no significant effect of cane production on household diet diversity. Nonetheless, annual income from a salary, maximum adult female education, number of live small animals and total household value of assets significantly increased the dietary diversity of a household. Variables such as being in Bunyoro sub region in comparison to being in Buganda, other religions (traditionalists) in comparison to Catholics, households' experiences of natural shocks (drought, floods, mudslides) and death of a household member negatively affected the dietary diversity of a household. Table 9-Col. (4) provides estimates with interaction terms and these results mimic those in Col (3) however the distance to the district given that you are a cane grower increase dietary divert while the interaction between cane growing and being in Buganda reduces the dietary diversity.

Concerning MAHFP (Table 9-Col (5)) show that households engaged in growing cane are expected to have 1.06 additional months of adequate food provisions and it is statistically significant ($p<0.05$). Insights here show that being able to overcome seasonality shifts in production and diets seems to be a positive outcome of cane growing. Being a male head, having maximum adult female education which is high, the number of large animals and number of crops grown are expected to have additional increase in the MAHFP. Regional level factors such as households in Busoga and Bunyoro in comparison to Buganda are expected to have 1.65 and 1.06 reduction in the MAHFP and the household size (measured as adult household equivalent) had a 0.177 reduction on MAHFP, and these are statistically significant at $p<0.05$.

Table 9: Poisson regressions of Household Food Insecurity Access Score (HFIAS), Household Dietary Diversity Score (HDDS), and Months of Adequate Household Food Provisions (MAHFP)

	HFIAS		HDDS		MAHFP	
	(1)	(2)	(3)	(4)	(5)	(6)
Selected variables	Marginal effects	Marginal effects	Marginal effects	Marginal effects	Marginal effects	Marginal effects
Hh cane grower (1 if yes)	-1.181*		0.270		1.060**	
	(0.0446)		(0.150)		(0.000425)	
Sex of household head (1 if male)	-1.492*	-1.694+	0.160	0.238	0.704+	0.984+
	(0.0373)	(0.0509)	(0.528)	(0.464)	(0.0707)	(0.0865)
Age of household head (yrs)	-0.0404+	-0.0418+	-0.00316	-0.00283	0.00217	0.00371
	(0.0830)	(0.0736)	(0.680)	(0.710)	(0.839)	(0.715)
Subregion (Base=Buganda)						
Busoga	3.218**	3.096**	0.235	-0.152	-1.654**	-2.268**
	(2.27e-08)	(2.90e-05)	(0.270)	(0.642)	(2.76e-07)	(5.59e-06)

	HFIAS		HDDS		MAHFP	
	(1)	(2)	(3)	(4)	(5)	(6)
Bunyoyo	3.303**	3.209**	-0.482*	-0.877*	-1.062**	-1.611**
	(1.41e-05)	(0.00109)	(0.0437)	(0.0174)	(0.00836)	(0.00772)
Total household land size	-0.0207	-0.0203	0.000458	0.000280	0.000883	0.00109*
	(0.335)	(0.331)	(0.358)	(0.579)	(0.104)	(0.0480)
Household equivalent (size)	0.672**	0.662**	0.0250	0.0232	-0.177**	-0.176**
	(3.01e-10)	(3.39e-10)	(0.547)	(0.577)	(0.00556)	(0.00411)
Log of annual income-salary	-0.212*	-0.210*	0.0595**	0.0593**	0.0466	0.0493
	(0.0102)	(0.0111)	(0.00882)	(0.00932)	(0.159)	(0.144)
Log of annual income-wage	0.0931+	0.0969*	0.00472	0.00544	-0.0343	-0.0340
	(0.0534)	(0.0448)	(0.782)	(0.753)	(0.186)	(0.184)
Maximum adult female education	-0.197**	-0.190*	0.0640*	0.0636*	0.109**	0.106**
	(0.00755)	(0.0105)	(0.0104)	(0.0117)	(0.00448)	(0.00466)
Maximum adult male education	-0.125	-0.130+	0.0419	0.0431	0.0267	0.0314
	(0.108)	(0.0971)	(0.135)	(0.123)	(0.388)	(0.306)
Religion of head (base=Catholic)						
Anglican	-0.0922	-0.0738	0.116	0.0995	0.379	0.332
	(0.911)	(0.929)	(0.662)	(0.709)	(0.399)	(0.444)
Other Christian	0.0416	0.114	-0.108	-0.120	0.792	0.804
	(0.973)	(0.927)	(0.777)	(0.752)	(0.119)	(0.108)
Muslim	0.156	0.148	0.160	0.174	0.496	0.507
	(0.870)	(0.876)	(0.574)	(0.536)	(0.374)	(0.358)
Other	6.649**	6.391**	-1.204**	-1.173**	-1.066	-1.167
	(0.000640)	(0.000661)	(0.00219)	(0.00320)	(0.246)	(0.171)
HH shock experiences						
Natural shocks (floods, drought landslides)	0.332	0.333	-0.469*	-0.461*	0.180	0.180
	(0.629)	(0.628)	(0.0174)	(0.0196)	(0.644)	(0.643)
Crop pests and diseases	1.747**	1.753**	0.327	0.321	-0.385	-0.428
	(0.00781)	(0.00769)	(0.104)	(0.108)	(0.279)	(0.221)
Death of hh member	0.817	0.727	-0.650*	-0.628+	-0.861	-0.892+
	(0.384)	(0.430)	(0.0493)	(0.0568)	(0.106)	(0.0883)
Other	0.357	0.336	-0.0959	-0.0935	-0.437	-0.448
	(0.618)	(0.636)	(0.629)	(0.641)	(0.255)	(0.231)
hh livestock ownership (#)						
# live large animals	-1.038+	-1.042+	0.220	0.210	0.442*	0.422+
	(0.0794)	(0.0817)	(0.233)	(0.251)	(0.0490)	(0.0606)
# live medium animals	-0.330	-0.343	0.0976	0.109	0.0699	0.0785
	(0.310)	(0.299)	(0.306)	(0.255)	(0.606)	(0.563)
# live small animals	0.0173	0.0172	0.217**	0.226**	0.112	0.118
	(0.960)	(0.960)	(0.00707)	(0.00567)	(0.371)	(0.350)
Log of household value of asset	-0.441**	-0.441**	0.170**	0.171**	-0.0395	-0.0289
	(7.13e-09)	(1.07e-08)	(0.00178)	(0.00197)	(0.379)	(0.529)
Distance to district (miles)	0.0612+	0.0495	-0.000255	0.00418	-0.00988	-0.00126
	(0.0697)	(0.275)	(0.984)	(0.824)	(0.629)	(0.968)
Distance to market (miles)	0.00806	0.0350	0.0134	-0.0189	0.0111	0.0293
	(0.878)	(0.612)	(0.389)	(0.407)	(0.669)	(0.352)
# of food crops grown	-0.499**	-0.489**	0.0509	0.0462	0.115+	0.110

	HFIAS		HDDS		MAHFP	
	(1)	(2)	(3)	(4)	(5)	(6)
	(0.00725)	(0.00828)	(0.269)	(0.314)	(0.0958)	(0.108)
Interaction terms						
hhcane*hhsex		0.722		-0.222		-0.781
		(0.543)		(0.589)		(0.266)
hhcane*dist_district		-0.0733		0.0571+		-0.0553
		(0.474)		(0.0531)		(0.252)
hhcane*dist_market		0.0385		-0.00852		-0.0176
		(0.533)		(0.687)		(0.613)
hhcane*buganda		-0.486		-0.812+		-1.100*
		(0.727)		(0.0695)		(0.0464)
hhcane* busoga		0.305		-0.0831		0.177
		(0.775)		(0.836)		(0.776)
Observations	1,769	1,769	1,767	1,767	1,769	1,769

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1, + p<1

4.3.2 Ordered probit correlates of HFIAS and sugarcane growing

Ordered probit analysis of HFIAS is implemented to provide additional insight into correlations between cane participation and other factors and food insecurity and the degree of it. Results of the determinants of food security using the HFIAS from the ordered probit model are presented in Table 10. The HFIAS was ordered, and the categories were significant ($p < 0.001$) (Table 10). The threshold value indicating the food insecurity categories; μ_1, μ_2, and μ_3 (cut1, cut2, and cut3) indicated that the categories are ranked in an ordered manner. The dependent variable is the food insecurity prevalence levels where the HFIAS values from 0 to 27 are categorized into four outcomes including: 0=food secure; 1=mildly food insecure, 2=Moderately food insecure, and 3=severely food insecure. The predicted probabilities of Y = 1 or the marginal effects were estimated, which measured changes in the probability of a food insecurity (access) outcome with respect to a one-unit change in an explanatory variable. The marginal effects of the respective models presented in Cols (2), (3), (4), and (5) are discussed since the coefficients of the ordered probit model (Col. (1)) do not show the magnitude of the effect of the independent variables (HFIAS)[7].

From Table 10, sugarcane growing households were likely to be in food secure and mildly food insecure levels while they were less likely to be in the moderately and severely food insecure categories. While the results have the rights causal signs, these are not significant at any level. Results further results show that household with older household head were likely to be in the food secure and mildly food insecure categories but less likely to be in the moderately and severely food insecure households. This possible when household age of head is associated with more experience and wealth. Households located in Busoga and Bunyoro were less likely to be food secure and mildly food insecure, however these were more likely to be in the moderately and severely food insecure categories. Household equivalent (size) highlights that an additional member makes a household more likely to fall in the severely and moderately food insecure categories but less likely to fall under the food secure and mildly food insecure categories. This is consistent with most studies which also find that an additional member implies more resources demand and more caloric requirements for the extra member from the already merge resources available to the household (Kirimi, *ud*).

Household growing more than one variety of food crops, owning highly valued household assets, earning a salary from a non-agricultural source, with highly educated adult females are more likely to be food secure and moderately food secure and less likely to fall in the moderately and severely food insecure categories. On maximum adult female education attainment, shows the critical importance

7 The interpretation of the marginal effects is based solely on the sign of the food security category. A negative sign of any category would mean an increase in that variable will decrease the probability of being in that food security category, whereas a category's positive coefficients mean an increase in that variable will increase the probability of being in that food security category.

of educated adult females in a home as these are also likely to work and bring in an income to supplement household food needs. Household value of assets shows the critical importance of having the right assets. They might be few but highly values and their sale fetch more resources to smoothen food consumption needs for a longer period than less valued assets.

Practicing other non-mainstream religions (traditionalists in comparison to being a Catholic), household experiencing crop pests and diseases, death of a household member and distance to the district are more likely to be categorised in the severely food insecure category and less likely to be in the food secure and mildly food insecure categories. This implies that for example, an additional mile to the district travelled by a household makes them more likely to be severely food insecure. The further the district is from a household the more difficult it become for it to engage meaningfully in attaining requisite information, food access and getting better paying jobs off the farm.

Table 10: Ordered probit of Household food Insecurity Access Scale (HFIAS)

		Marginal effects			
	(1)	(2)	(3)	(4)	(5)
		Food secure	Mildly food insecure	Moderately food insecure	Severely food insecure
Selected variables	Ordered probit coeff.	Y=1	Y=2	Y=3	Y=4
HH cane grower (1 if yes)	-0.0362	0.0106	0.00153	-0.00215	-0.0108
	(0.121)	(0.0350)	(0.00516)	(0.00696)	(0.0362)
Sex of household head (1 if male)	-0.280	0.0816	0.0119	-0.0163	-0.0841
	(0.176)	(0.0524)	(0.00740)	(0.0130)	(0.0529)
Age of household head (yrs)	-0.0105**	0.00305**	0.000444**	-0.000609*	-0.00315**
	(0.00456)	(0.00131)	(0.000215)	(0.000358)	(0.00139)
Subregion (Base=Buganda)					
Busoga	0.508***	-0.167***	-0.0162***	0.0628***	0.130***
	(0.137)	(0.0452)	(0.00600)	(0.0219)	(0.0338)
Bunyoyo	0.570***	-0.184***	-0.0193***	0.0639***	0.150***
	(0.160)	(0.0498)	(0.00729)	(0.0217)	(0.0445)
Household equivalent (size)	0.114***	-0.0332***	-0.00482***	0.00662**	0.0342***
	(0.0232)	(0.00741)	(0.00122)	(0.00333)	(0.00705)
Log of annual income-salary	-0.0330**	0.00963**	0.00140**	-0.00192*	-0.00992**
	(0.0136)	(0.00394)	(0.000666)	(0.00115)	(0.00410)
Log of annual income-wage	0.00707	-0.00206	-0.000299	0.000411	0.00212
	(0.0111)	(0.00320)	(0.000486)	(0.000669)	(0.00333)
Maximum adult female education	-0.0429***	0.0125***	0.00182**	-0.00249*	-0.0129***
	(0.0150)	(0.00438)	(0.000738)	(0.00144)	(0.00448)
Maximum adult male education	-0.0170	0.00495	0.000720	-0.000987	-0.00510
	(0.0167)	(0.00484)	(0.000750)	(0.00104)	(0.00505)
Religion of head (base=Catholic)					
Anglican	-0.133	0.0394	0.00559	-0.00867	-0.0395
	(0.162)	(0.0476)	(0.00705)	(0.0105)	(0.0488)
Other Christian	-0.0125	0.00352	0.000562	-0.000517	-0.00387
	(0.231)	(0.0652)	(0.0104)	(0.00977)	(0.0715)
Muslim	-0.0163	0.00459	0.000730	-0.000685	-0.00503
	(0.190)	(0.0536)	(0.00854)	(0.00802)	(0.0588)

		Marginal effects			
	(1)	(2)	(3)	(4)	(5)
		Food secure	Mildly food insecure	Moderately food insecure	Severely food insecure
Other	1.176**	-0.178***	-0.0619***	-0.182	0.441***
	(0.483)	(0.0463)	(0.0233)	(0.122)	(0.171)
HH shock experiences					
Natural shocks (floods, drought landslides)	0.144	-0.0421	-0.00597	0.00877	0.0429
	(0.138)	(0.0413)	(0.00567)	(0.0104)	(0.0403)
Crop pests and diseases	0.414***	-0.113***	-0.0192***	0.0110	0.131***
	(0.132)	(0.0358)	(0.00729)	(0.0106)	(0.0454)
Death of hh member	0.412**	-0.102***	-0.0206**	-0.00686	0.139**
	(0.171)	(0.0368)	(0.0100)	(0.0170)	(0.0626)
Other	0.129	-0.0365	-0.00569	0.00580	0.0395
	(0.153)	(0.0419)	(0.00724)	(0.00597)	(0.0480)
hh livestock ownership (#)					
# livelarge animals	-0.134	0.0391	0.00569	-0.00780	-0.0403
	(0.116)	(0.0335)	(0.00517)	(0.00725)	(0.0350)
# livemedium animals	-0.0816	0.0238	0.00346	-0.00474	-0.0245
	(0.0646)	(0.0190)	(0.00277)	(0.00433)	(0.0195)
# live small animals	0.00153	-0.000445	-6.47e-05	8.87e-05	0.000459
	(0.0551)	(0.0160)	(0.00233)	(0.00320)	(0.0165)
Log of household asset value	-0.137***	0.0400***	0.00582***	-0.00798**	-0.0413***
	(0.0293)	(0.00925)	(0.00134)	(0.00384)	(0.00905)
Distance to district (miles)	0.0152**	-0.00443**	-0.000644*	0.000883	0.00457**
	(0.00746)	(0.00218)	(0.000339)	(0.000557)	(0.00227)
Distance to market (miles)	-0.00557	0.00162	0.000236	-0.000324	-0.00167
	(0.00987)	(0.00284)	(0.000428)	(0.000542)	(0.00299)
# of food crops grown	-0.109***	0.0318***	0.00463**	-0.00635*	-0.0328***
	(0.0386)	(0.0112)	(0.00185)	(0.00353)	(0.0117)
/cut1	-2.816***				
	(0.508)				
/cut2	-2.487***				
	(0.514)				
/cut3	-1.270**				
	(0.505)				
Observations	1,771	1,771	1,771	1,771	1,771

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

4.3.3 Sensitivity and robustness checks

Table 11 shows the detailed results of different matching techniques use to estimate the impact of sugarcane production on the three food security measures. The analysis is adjusted using all explanatory variables included in the Poisson regression model.

Using the NNMatch and IPW matching methods, the average treatment on the treated (ATT) of cane production on HDDS is statistically significant and unexpectedly negative. This implies that growing cane is associated with a -0.33-point reduction in HDDS for cane growers, though this is only about a 4% reduction (Table 11, Col 2). Likewise, the PSM (1:1) matching method finds a statistically significant and negative association between growing cane and HDDS for both growers and non-growers (Average Treatment Effect), though the magnitude is quite small. The ATC (average treatment on the untreated) on the HFIAS of non-cane

growers indicates that if they were to grow cane, their food insecurity be reduced by -0.8 and their months of adequate food provision would increase by 0.4 months.

The Mahalanobis-distance kernel matching, NNMatch and PSM (1:1) estimators all find a statistically significant and positive association of cane growing with a 0.4 increase in the months of adequate food provision. That means that if a non-cane grower were to decide to grow cane, these matching methods estimate that their food insecurity would fall (HFIAS) slightly, and their months of food provision would increase by nearly half a month. None of the impact measurements using the PSM-kernel matching approach were statistically significant.

While the latter results above suggest that cane production could benefit farmers that currently do not grow cane, the matching results need to be taken with caution, as the key assumption underlying matching methods is that after controlling for explanatory variables that are observed, there are no known factors that are unobserved – i.e. not included as an explanatory variable-- that are expected to affect household food security, yet may also be correlated with cane production. If that is the case, then impact estimates from matching approaches can be biased just as endogeneity from omitted variables in regression analysis (a form of endogeneity) can bias program intervention dummies or other variables in a model. In this case, it seems that the assumption required for unbiased matching is strong given that we do not have a measure of expected or actual rainfall or other variables measuring agroecological potential.

Graphical diagnosis assisted our observation of the distribution of propensity scores between treatment and control groups through use of Kernel density plots, cumulative density plots and a box whisker plot. The graphical representation of some of our matching model techniques show how matching successfully reduced bias between the treated and the untreated (Figure 16 and 17). Figure 17 demonstrates that the difference in the means of the propensity scores for the two groups being compared were small, where the means must be less than half a standard deviation apart. Likewise, the distributions of the covariates in both groups are nearly symmetric in the matched sample and the distributions of the covariates in both groups have nearly the same variances.

Table 11: Impact of sugarcane growing on HFIAS, HDDS and MAHFP

Impact estimation methods	Mahalanobis-distance kernel			NNMatch			IPW			PSM (1:1)			PSM-Kernel		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
	hfias	hdds	mahfp	hfias	hdds	mahfp	hfias	hdds	mahfp	hfias	hdds	mahfp	hfias	hdds	mahfp
ATE	0.275	-0.0279	0.00437	0.914	-0.281	-0.189	-0.173	-0.206*	0.000146	-0.324	-0.268*	0.122	-0.180	-0.113	0.0355
	(0.557)	(0.177)	(0.240)	(0.725)	(0.211)	(0.277)	(0.302)	(0.117)	(0.130)	(0.501)	(0.152)	(0.181)	(0.417)	(0.133)	(0.163)
ATT	1.148	-0.198	-0.340	2.138	-0.632*	-0.659	-0.174	-0.333**	-0.173	-0.405	-0.202	-0.103	-0.291	-0.126	-0.137
	(0.875)	(0.272)	(0.392)	(1.311)	(0.341)	(0.498)	(0.351)	(0.150)	(0.139)	(0.783)	(0.222)	(0.283)	(0.634)	(0.206)	(0.197)
ATC	-0.836**	0.189	0.443***	-0.618	0.158	0.400**	-0.173	-0.0461	0.216	-0.223	-0.350*	0.402*	-0.0421	-0.0980	0.250
	(0.355)	(0.119)	(0.147)	(0.511)	(0.152)	(0.193)	(0.381)	(0.129)	(0.171)	(0.498)	(0.208)	(0.225)	(0.375)	(0.117)	(0.218)
Observations	1,766	1,766	1,766	1,766	1,766	1,766	1,766	1,766	1,766	1,766	1,766	1,766	1,766	1,766	1,766

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: ATE is the average treatment effects.; ATT is the average treatment effects on the treated; ATC is the average treatment effects on the untreated

Mahalanobis-distance kernel matching with post matching regression adjustment NNMatch-Mahanobis with Nearest-Neighbour Matching (1:1) with replacement and post matching regression adjustment IPW-Inverse probability weighting with regression adjustment; PSM-nearest neighbour matching (1:1) with regression adjustment and PSM-Kernel matching with regression adjustment

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Figure 16: Distance matching

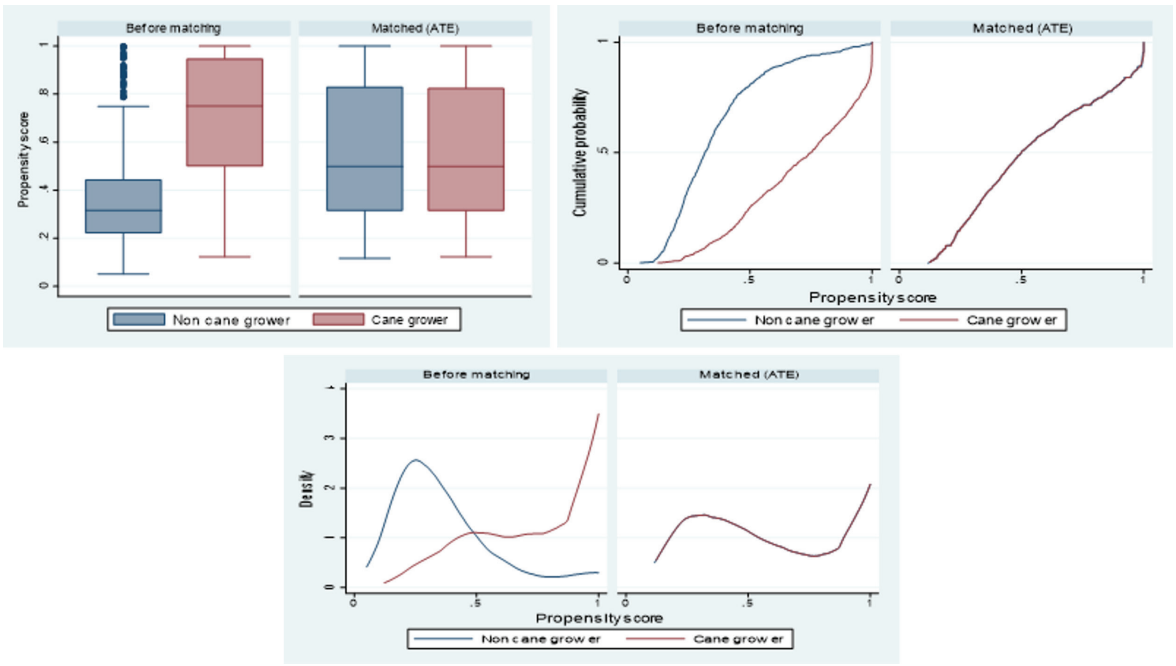


Figure 17: One-to-one nearest neighbour

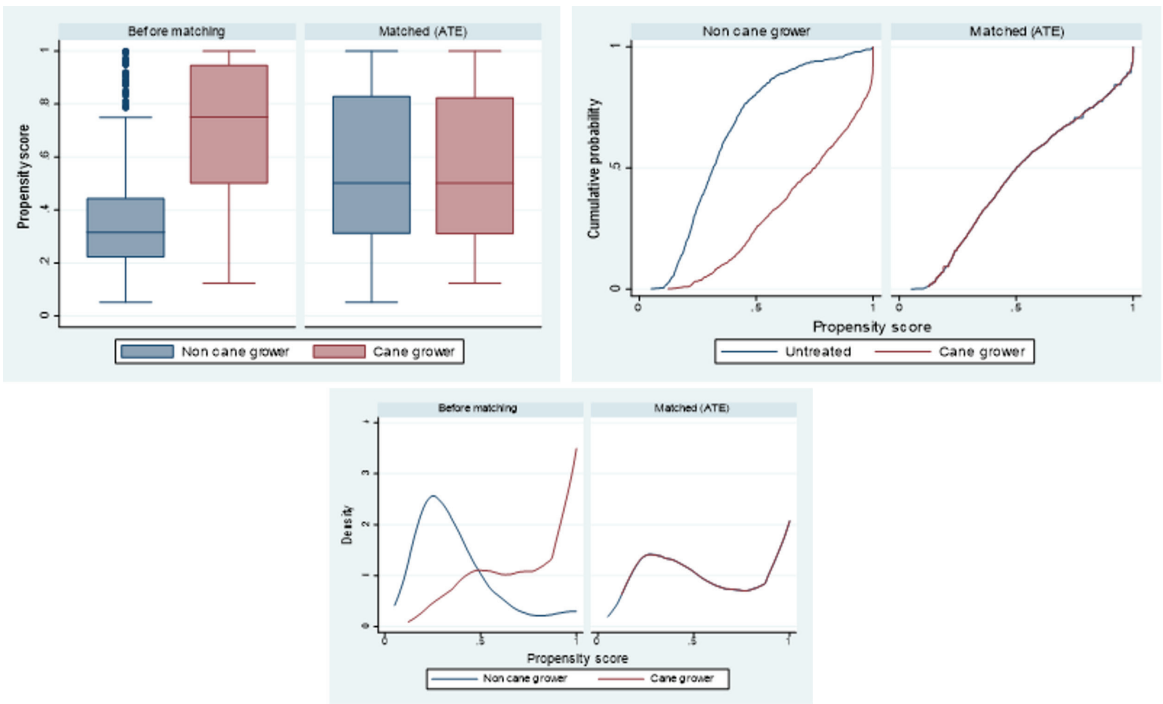
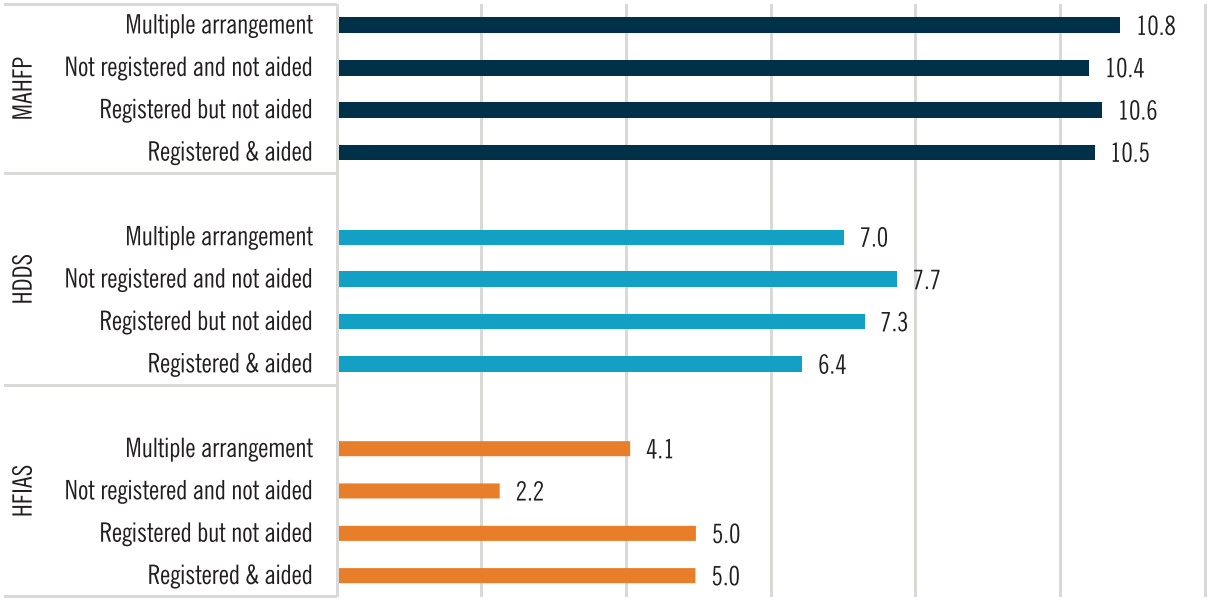


Figure 18: Mean values of food security measures by miller-outgrower arrangements



Notes: Number of strata=3; Number of PSUs=36; Number of obs=590; Population size=14,229.4; Design df=33
Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

4.4 Are differences in institutional arrangements between millers and growers associated with differences in the household food security of cane producers?

The second research question of this study is whether, among cane growers, household food security varies by type of grower-miller institutional arrangement. We use descriptive analysis only as it is not feasible to include dummies of 3 of the 4 institutional arrangements into our food security regressions as such variables are likely endogenous and there is only one instrument that appears to be valid for them.

Households that were not registered and not aided had better HFIAS and HDDS scores than those with some form of grower-miller arrangement, followed by farmers with multiple arrangements (any two of the 4 institutional arrangement categories in Figure 18). Interestingly, households that were registered and aided had worse scores across our food security measurement indicators. Based on findings from recent analysis on cane productivity and profitability in Uganda (Mbowa et al, 2023b), it is likely that cane growers in Busoga are driving this result, as many were registered or registered-aided, yet few in Busoga saw benefits from those institutional arrangements in 2021 due to a near collapse in coordination between millers and growers. Households that were not registered and not aided had the lowest MAHFP score, yet the difference was not statistically significant from that of registered and aided households. Note that these figures considered only households that sold cane in 2021 but not those that were growing cane and had not yet sold. Including those households would make it less likely that any expected positive association between registration or registration with aid and household food security is found. These results should thus be interpreted with caution.

4.5 Does women's involvement in household decisions regarding crop choice, crop marketing, and use of crop sales income influence household food security outcomes?

4.5.1 Women's influence on household cropping decisions

Among cane grower households, those with male heads that control decision-making on cropping decisions for all the household's land parcels had relatively lower HFIAS -- better food security -- than households where either a female head controlled all land parcels, or the household used joint husband-wife decision-making for all parcels. The HFIAS was 5.57, HDDS-6.74 and MAHFP-10.37. All parcels/plots owned by a household on which decisions made were solely

by female heads/spouse had the worst food security outcome measures with HFIAS-8.45, HDDs-5.79 and MAHFP-10.1 (Table 12). The key insight here is that households where a female head/spouse controls decision-making for cropping decisions – which are nearly all female-headed households - are more likely to be food insecure than other households, regardless of whether they are cane growers or non-cane growers. Second, it is important to note that female headed households are more resource-constrained, on average, than male headed ones, and that results above indicate that households with lower landholding and asset levels have relatively worse food security outcomes. The implication is that we cannot deduce explicitly from a comparison of mean food security measures by the gender of the household decision maker on cropping decisions or a household's cane growing status whether the relationship between women's influence on household cropping decisions and household food security outcomes varies by cane growing status.

Table 12: Average of Household food security measures by the gender and household position of the final decision-maker on crop choices to plant on household parcels, by cane participation status

Who makes the final decision on what to plant on plot at household	Non-Cane growers			Cane grower			All		
	Mean	Linearised std. err.	CV (%)	Mean	Linearised std. err.	CV (%)	Mean	Linearised std. err.	CV (%)
HFIAS									
Male head	6.61	0.4959	7.5	5.47	0.3460	6.3	6.10	0.3440	5.6
Female head/spouse	9.16	0.7025	7.7	8.45	1.0459	12.4	8.94	0.6258	7.0
Jointly Husband and spouse	7.24	1.3953	19.3	6.26	0.5373	8.6	6.91	0.8782	12.7
Other members and mixed allocation	11.04	1.4971	13.6	6.27	0.4985	8.0	8.76	0.6167	7.0
HDDS									
Male head	6.36	0.1747	2.7	6.74	0.1190	1.8	6.53	0.1137	1.7
Female head/spouse	5.42	0.1721	3.2	5.79	0.4586	7.9	5.54	0.1871	3.4
Jointly Husband and spouse	6.30	0.3015	4.8	6.74	0.1131	1.7	6.45	0.2182	3.4
Other members and mixed allocation	4.94	0.4864	9.8	6.68	0.1065	1.6	5.77	0.2707	4.7
MAHFP									
Male head	9.53	0.1256	1.3	10.37	0.1215	1.2	9.90	0.0951	1.0
Female head/spouse	8.88	0.3058	3.4	10.06	0.3007	3.0	9.25	0.2992	3.2
Jointly Husband and spouse	9.35	0.3577	3.8	10.32	0.1468	1.4	9.68	0.3102	3.2
Other members and mixed allocation	7.52	0.9057	12.0	10.31	0.3113	3.0	8.86	0.3148	3.6
No. of observations	*787*			*981*			*1,768*		
Population size	*41,843*			*28,656*			*70,498*		
Number of strata	*3*			*3*			*3*		
Number of PSUs	*36*			*36*			*36*		

Notes: The decision-making categories are mutually exclusive

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Next, we estimate a Poisson model (for only cane grower households) of HFIAS, HDDS and MAHFP that includes all the explanatory variables in prior specifications, with the inclusion of a dummy variable that =1 for households where a female head/spouse has the final say on cropping choices (and =0 otherwise) and a dummy variable that =1 for households where there is joint (both husband and wife) say on the final crops grown on plots. We also drop the dummy variable control that =1 if the household is male headed (and =0 otherwise) from the original specifications. The inclusion of this female-headed household dummy should capture any average differences in food security outcomes between male and female headed sugarcane growing households after controlling separately for total

household landing, asset values, and other factors[8]. awe note HFIAS (food insecurity access) Col (1) female headship alone had no significant effect. While Col (3) also highlights that inclusion of joint decision-making on plots increased the food insecurity access score by 1.37 units (20% increase) while female head/spouse increased the food insecurity score by 3.73 units (57% increase), much higher than in Col (2) and this is significant at $p<0.005$ and $p<0.1$ respectively. The statistically significant partial effect of these dummy indicates that HFIAS increased for sugarcane growing households that have strong women's influence on crop choice ($p<0.1$) (Table 13, Col.2 & 3). This result is not only the opposite of our expectation, but of such a large magnitude that it suggests that the female head/spouse cropping choice dummy may be capturing some of the negative association of female headedness with household food security – a common finding.

The results for HDDS and MAHFP (Table 13 cols. 4 to 9) were not significant regarding causal effect of female decision making on what to plant on a plot on dietary diversity and months of adequate food provisions. The complete Table estimates are provided in Appendix Table 3.

8 The addition of the female headed household dummy helps to control for unobserved factors that may associated with such households and their food security outcomes. For e.g., if female headed households tend to have lower food security measures relative to male headed households due to lower levels of social capital, then the failure to include the female headed household dummy in the model would likely mean that the dummy that =1 for female head/spouse control of crop choice would capture that negative association between the gender of the household head and food security. This could subsequently confound our intended test of the women's influence dummy in the food security regression.

Figure 13: Poisson model estimates of food security and gender and position of household member making final decisions on crop choices

VARIABLES	HFIAS			HDDS			MAHFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Mfx	mfx	mfx	mfx	mfx	mfx	mfx	mfx	mfx
Decision on what to plant on plot									
Female head/spouse(dummy)		3.529**	3.730**		-0.497	-0.518		-0.689	-0.678
		(0.00242)	(0.00123)		(0.154)	(0.140)		(0.155)	(0.166)
Jointly by husband and wife (dummy)			1.366*			-0.173			0.102
			(0.0249)			(0.442)			(0.680)
Sex of household head (1 if female)	0.688	-1.770	-1.761	0.118	0.445	0.443	-0.276	0.178	0.180
	(0.323)	(0.116)	(0.110)	(0.663)	(0.225)	(0.225)	(0.401)	(0.715)	(0.712)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Institutional & location characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Agricultural characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	975	974	974	974	973	973	975	974	974

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

4.5.2 Women's influence on household decision-making on crop marketing

We next investigate whether women's influence on household food security might be seen in the household's decisions regarding crop marketing. Like 4.5.1, we create two dummy indicators of women's influence on household crop marketing decisions; one =1 if a female head/spouse has the final say on crop marketing on all parcels, and a separate dummy =1 if this decision is made jointly by the husband and wife for all parcels. Decision making on marketing on what has been harvested from the plots shows that, where female heads/spouses where solely in charge, HFIAS was high especially among non-cane growers compared to what the cane growers score was like. The same applies to having a relatively lower HDDS. However, the female heads/ spouses show a slightly more months of adequate household provisions for cane grower households (Table 14).

Figure 14: Food security and gender and household position of household member making final decisions on crop marketing

	Non-Cane growers			Cane grower			All		
	Mean	Linearised std. err.	CV(%)	Mean	Linearised std. err.	CV (%)	Mean	Linearised std. err.	CV (%)
HFIAS									
Male head	6.17	0.7909	12.8	5.31	0.3559	6.7	5.77	0.5441	9.4
Female head/spouse	10.31	1.0168	9.9	7.85	1.0999	14.0	9.57	0.8940	9.3
Jointly Husband and spouse	8.20	0.8498	10.4	5.88	0.5309	9.0	7.50	0.5589	7.5
Other members and mixed allocation	8.14	0.8490	10.4	7.10	0.4829	6.8	7.63	0.4070	5.3
HDDS									
Male head	6.45	0.2723	4.2	6.76	0.1448	2.1	6.59	0.1869	2.8
Female head/spouse	5.30	0.2261	4.3	5.92	0.3760	6.4	5.49	0.2112	3.8
Jointly Husband and spouse	6.29	0.2218	3.5	6.66	0.1428	2.1	6.40	0.1332	2.1
Other members and mixed allocation	5.22	0.2286	4.4	6.61	0.1785	2.7	5.91	0.1696	2.9
MAHFP									
Male head	9.67	0.1907	2.0	10.41	0.1379	1.3	10.01	0.1398	1.4
Female head/spouse	8.18	0.6112	7.5	10.52	0.4464	4.2	8.89	0.3576	4.0
Jointly Husband and spouse	8.95	0.4813	5.4	9.92	0.3933	4.0	9.24	0.5051	5.5
Other members and mixed allocation	9.14	0.1906	2.1	10.19	0.2322	2.3	9.66	0.1254	1.3
No. of observations	*787*			*981*			*1,768*		
Population size	*41,843*			*28,656*			*70,498*		
Number of strata	*3*			*3*			*3*		
Number of PSUs	*36*			*36*			*36*		

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

To test the robustness of the findings in this section, we also tried two alternative measures of women's influence on household crop choice and crop marketing for sugarcane growing households only. For the first alternative measure of women's influence on household decisions regarding household decision-making on crop marketing and then on allocation of income from crop sales, while the results for these dummy variables in the regressions of food security are slightly different in magnitude, they are not statistically significant (Table 15), thus there is still no evidence that households where a female head/spouse has the final say on intra-household decisions on crop choice, crop marketing, and/or allocation of sales crop income is associated with better HFIAS food security outcomes. There are also no statistically significant associations between the decision dummy and the HDDS or MAHFP outcomes. Detailed estimates are provided in Appendix Table 4.

The second alternative measure of women's influence is measured as the share of total household area cultivated from plots where a female head/spouse has the final decision on cropping choice (and then separately, on crop marketing, and on allocation of income from crop sales). The results of using this alternative measure are similar to those with the first alternative – none of the dummies indicating that a female head/spouse had the final say on any of the three decisions were statistically significant. This may reflect the fact that most households where a female head/spouse has the final decision on crop marketing (or crop choice or allocation of crop sales income) are female headed households – and their lower asset base on average and few household income earners typically means that their household food security outcomes are lower than those of male headed households.

Figure 15: Poisson model estimates on who decides how to allocate crop production harvested on this parcel? (e.g. whether to sell, consume etc) on household food security

	HFIAS			HDDS			MAHFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	mfx	mfx	mfx	mfx	mfx	mfx	mfx	mfx	mfx
Allocation of proceeds from plot									
Female head/spouse		2.096	2.186		-0.296	-0.321		0.213	0.173
		(0.153)	(0.138)		(0.370)	(0.336)		(0.665)	(0.726)
Jointly by husband and wife			0.504			-0.147			-0.259
			(0.490)			(0.517)			(0.373)
Sex of household head (1 if female)	0.688	-0.782	-0.774	0.118	0.320	0.320	-0.276	-0.426	-0.428
	(0.323)	(0.564)	(0.563)	(0.663)	(0.393)	(0.392)	(0.401)	(0.426)	(0.422)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Institutional & location characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Agricultural characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	975	974	974	974	973	973	975	974	974

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

5. CONCLUSION AND POLICY RECOMMENDATIONS

This study investigates the relationship between farm household participation in sugarcane production and food security within the main sugarcane-growing sub regions of Buganda, Busoga and Bunyoro in Uganda. The study also investigates whether women's influence in intra-household decision-making in crop production and marketing is associated with better food security outcomes. The study used three measures of food security, the HFIAS, HDDS and MAHFP to estimate the food security status of 1,171 households of which 983 were cane growers and 788 were non cane growers. A Poisson and ordered probit model were used to investigate the relationship between cane production and food security, while controlling for a variety of household and community-level factors known to influence household food security. The use of the three measures helps the study to compare and validate the three measures used. The choice of the model was done by first estimating a negative binomial and where it was not significant hence Poisson model fitted the data better.

Econometric analysis finds that sugarcane growing households were 17%t less food insecure, on average, relative to non-cane growers, as measured by the 27-point Household Food Insecurity Access Scale (HFIAS). –. Cane growing was also associated with one additional month of adequate household food provision (MAHFP), an improvement of 10% compared with non-cane growers. No significant association was found between cane production and HDDS, another measure of household food security. This analysis also found that households in Buganda subregion had better food security measures compared to those in Busoga and Bunyoro subregions, with Bunyoro faring the worst. The severity of food insecurity using the HFIAS is high among non-cane growers, though it declines in total household asset value and ownership of large animals. Households with less than two acres and those with less than 4 acres in non-cane and cane growing categories were severely food insecure, on average, for each of the three food security measures.

Other factors positively associated with food security outcomes included a household growing more than one food crop, one or more household members with salaried employment, and higher levels of maximum adult female education in the household, household assets, and number of live animals. Female education levels may promote better

food security outcomes as more educated female adults may be more likely to adopt improved crop production technology and farming practices that can promote higher farm income and household food security. The value of household assets (a form of saving) increases household resilience to adverse shocks on household food production and incomes and thus also affect food security (Kirimi, ud).

Factors negatively associated with food security status include household size (as measured by household Adult Equivalents), residence in Busoga and Bunyoro subregions relative to Buganda, having a member in wage employment, and female-headed household status. Larger households have higher consumption needs, often have higher dependency ratios, and are typically found to have lower food security, controlling for other factors.

Concerning maximum education of a female household member, a measure of human capital. Education, especially for an adult female, is important in enhancing skills and ability to make decisions which can enable access to better economic opportunities or better utilisation of information including use of technology and farming practices to improve agricultural production and hence food security. The value of household assets (a form of saving) increases the ability of a household to deal with shocks which bring about abrupt changes in food production, prices, and income, and so affect food security (Kirimi, *ud).* The adult equivalent variable may be synonymous with increased consumption needs and higher dependents that hardly contribute to food production or income generating activities that would promote food security. Results of testing whether a household female head/spouse or in joint decision-making positions have strong influence in intra-household decision making on crop choice or crop marketing show that is no evidence to support the expectation that those with strong influence on crop choice or crop marketing impact positively food security of a household.

In conclusion, food insecurity is a big problem in sugarcane growing subregions, with geographical differences which might impact Uganda's attainment of NDP and SDGs targets. Nonetheless, sugarcane growing yields some benefits on food security.

Policy recommendations

To harness the full potential of sugar cane growing for food security in Uganda, the following needs to be addressed:

- Human capital development, enhancing wealth assets in an integrated manner, diversification of food crops grown, household size and spatial development, control of pests & diseases, faith & beliefs (as this affects what is grown and eaten based on culture and what religious inclinations).
- Empowerment of women in decision-making at production matters for food security among cane growers.
- As the drive for agro- industrialisation takes shape, the identified crops under this programme such as sugarcane should not be championed in such a way that compromises food security. For example, it is important for new cane millers to adhere to the recommendation of the 2010 National Sugar Policy that emphasizes that 30% of land within a 25km radius of a mill is under sugarcane while 70% is maintained for food and other activities. Awareness of this requirement should be made and emphasized.
- Farmers with the intention of growing cane should have a minimum of 8-15 acres under intensive cane production with minimum of 1-2 acres under food. Note that larger scale farmers don't need to have this condition.

To safeguard the positive socio-economic impacts of sugarcane growing, such as food security and incomes, the following are recommended arising from the key insights from this is that there is need to:

a. Design spatial programmes for Busoga and Bunyoro to enhance food security that integrate human capital, wealth creation, crop diversification, among others such as the Northern Uganda Social Action Fund (NUSAF).
b. Guide farming households on enterprise selection that matches with available arable land size. Assuming the status quo, cane growers should have a minimum total land size of 15 acres. Non-cane growers will need to increase crop and/or livestock intensification to improve their food security.
c. Strengthen government collaboration with faith-based and cultural institutions in mobilising their communities to grow more food for household consumption and income.
d. Government should (MTIC & MAAIF) create an enabling policy environment to support stability in the

miller-out-grower relationship to keep households in circuits of commercial agriculture to sustain the population in the monetary economy. These should be geared towards transparency and timeliness in payment of harvested cane.

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APPENDIX

Appendix Table 1: HDDS food group classification

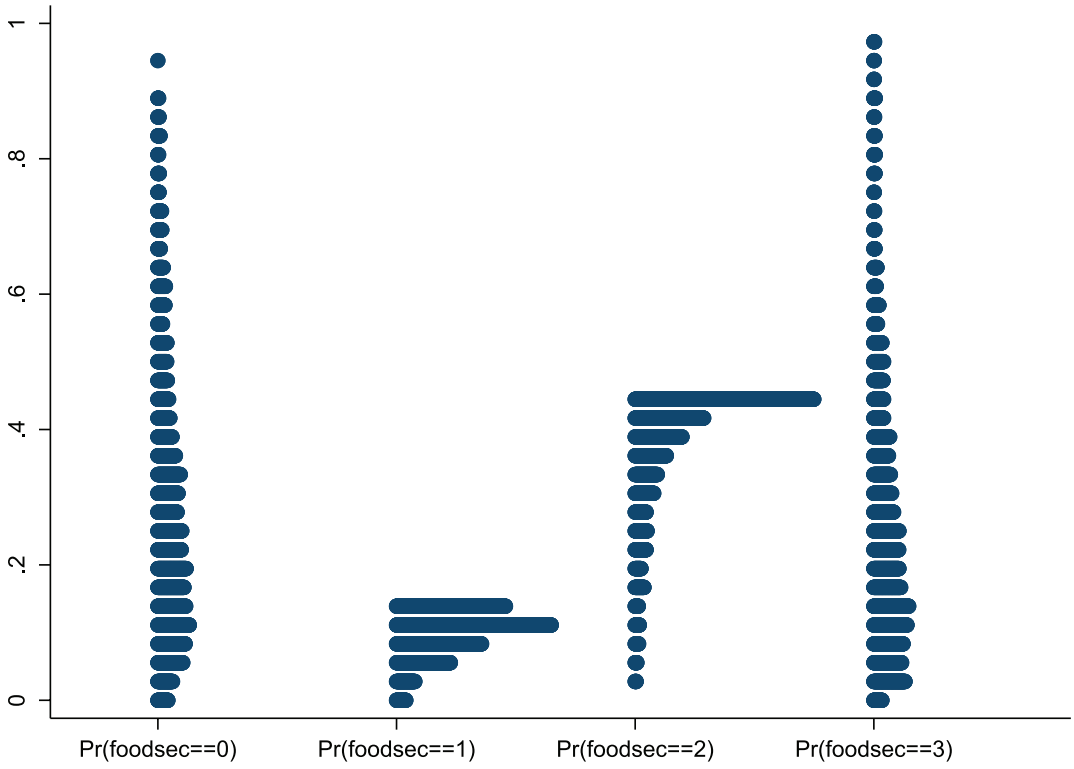
	Food group	Description
1	Cereals	Posho, porridge, rice, noodles, bread, biscuits, or any foods made from maize, rice, wheat, millet, sorghum, or any other grains
2	Roots and tubers	White or yellow potato, Irish potatoes, yam, white cassava, others
3	Milk and milk products	Milk, yoghurt, cheese, other dairy products (excludes butter/margarine)
4	Vegetables	Dark green leafy vegetables (Carrot, spinach, turnip, cabbage, cauliflower, broccoli, onion, tomato, cucumber, okra, Amaranthus, cassava leaves, pumpkin leaves, sweet potato leaves, kale) and others
5	Fruits	Apple, banana, guava, avocado, pear, peach, mango, papaya, melon, orange, lemon, mandarin orange, others
6	Meat, poultry, offal	Beef, chicken, pork, liver, kidney, heart, game meat, crocodile, duck, guinea fowl, pigeon, quail, insects, other birds
7	Eggs	Eggs by purchase or own production from chicken, duck, guinea fowl, crocodile
8	Fish	Fish (fresh and dried), canned tuna, other shellfish
9	Legumes, nuts, and seeds	Beans, chickpeas, broad beans, peas, others
10	Oils and fats	Butter, vegetable oil, palm oil, margarine, other fats
11	Sweets-Sugar/honey	Sugar, honey, jam; cakes, cookies, sodas and other sugary drinks
12	Miscellaneous	Drinks: tea, coffee, cocoa; seasonings, alcoholic beverages: salt, garlic, baking powder

Appendix Table 2: Household dietary diversity score (HDDS) and food insecurity access scale (HFIAS) by gender of household head and cane grower status, %

	Female head			Male head		
	Non-cane producer	Cane producer	Total	Non-cane producer	Cane producer	Total
Panel A: HDDS						
1	0.1	0.4	0.2	0.5	0.2	0.4
2	6.9	2.8	5.8	4.1	1.3	2.9
3	10.3	6.5	9.3	7.8	3.5	5.9
4	15.8	24.1	18.2	13.6	7.9	11.1
5	25.4	7.6	20.4	13.6	15.0	14.2
6	19.2	18.9	19.1	17.8	21.1	19.2
7	7.7	14.3	9.5	10.7	16.5	13.2
8	9.1	10.6	9.5	13.4	15.1	14.1
9	3.3	7.7	4.5	12.6	12.1	12.4
10	1.7	6.1	2.9	4.3	3.9	4.1
11	0.4	1.1	0.6	0.4	3.0	1.5
12	-	-	-	1.3	0.6	1.0
Panel B: HFIAS-Scale						
Food secure	16.2	23.2	18.2	26.7	28.0	27.3
Mildly food insecure	6.7	7.9	7.1	11.6	9.0	10.4
Moderately food insecure	35.9	35.7	35.8	36.1	43.7	39.4
Severely food insecure	41.2	33.1	38.9	25.7	19.4	22.9
Total	100	100	100	100	100	100

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Appendix Figure 1: Predictive power on the food security categories covariates on the outcome



Appendix Table 3: Poisson model estimates of sugarcane planting decisions on food security indicators

	HFIAS			HDDS			MAHFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	**mfx**	**mfx**	**mfx**	**mfx**	**mfx**	**mfx**	**mfx**	**mfx**	**mfx**
Decision on what to plant on plot									
Female head/spouse		3.529**	3.730**		-0.497	-0.518		-0.689	-0.678
		(0.00242)	(0.00123)		(0.154)	(0.140)		(0.155)	(0.166)
Jointly husband and wife			1.366*			-0.173			0.102
			(0.0249)			(0.442)			(0.680)
Sex of household head (1 if female)	0.688	-1.770	-1.761	0.118	0.445	0.443	-0.276	0.178	0.180
	(0.323)	(0.116)	(0.110)	(0.663)	(0.225)	(0.225)	(0.401)	(0.715)	(0.712)
Age of household head (yrs)	-0.0755**	-0.0853**	-0.0811**	-0.00106	0.000116	-0.000516	0.0193*	0.0208*	0.0212*
	(0.00236)	(0.000288)	(0.000432)	(0.865)	(0.985)	(0.933)	(0.0183)	(0.0119)	(0.0104)
Subregion (Base=Buganda)									
Busoga	2.806**	2.792**	2.851**	0.553*	0.565*	0.559*	-0.690*	-0.668*	-0.664*
	(2.03e-06)	(8.97e-07)	(2.74e-07)	(0.0162)	(0.0142)	(0.0152)	(0.0113)	(0.0150)	(0.0144)
Bunyoyo	2.932**	2.750**	2.768**	-0.286	-0.262	-0.260	-0.353	-0.310	-0.311
	(7.09e-05)	(5.07e-05)	(3.77e-05)	(0.263)	(0.308)	(0.310)	(0.258)	(0.334)	(0.332)
Log share of cane land	2.473	3.142+	3.396+	0.194	0.0935	0.0695	-1.007	-1.130	-1.116
	(0.195)	(0.0798)	(0.0576)	(0.709)	(0.859)	(0.894)	(0.174)	(0.129)	(0.136)
Household equivalent (size)	0.604**	0.657**	0.658**	0.00373	-0.000349	0.00152	-0.193**	-0.199**	-0.200**

	(5.59e-09)	(0)	(0)	(0.914)	(0.992)	(0.964)	(0.000251)	(0.000133)	(0.000144)
Log of annual income-salary	-0.102	-0.124	-0.127	0.00600	0.00756	0.00770	0.00142	0.00336	0.00334
	(0.185)	(0.112)	(0.101)	(0.744)	(0.675)	(0.666)	(0.957)	(0.896)	(0.897)
Log of annual income-wage	0.0834*	0.0727+	0.0761+	-0.00760	-0.00645	-0.00686	-0.0370	-0.0351	-0.0350
	(0.0385)	(0.0720)	(0.0532)	(0.649)	(0.696)	(0.675)	(0.106)	(0.124)	(0.124)
Maximum adult female education	-0.275**	-0.290**	-0.296**	0.0807**	0.0828**	0.0830**	0.0720**	0.0756**	0.0755**
	(0.000173)	(2.20e-06)	(1.37e-06)	(0.000627)	(0.000497)	(0.000454)	(0.00798)	(0.00546)	(0.00550)
Maximum adultmale education	-0.107+	-0.107*	-0.113*	0.0728**	0.0736**	0.0743**	0.0373	0.0379	0.0375
	(0.0530)	(0.0469)	(0.0354)	(0.00100)	(0.000958)	(0.000820)	(0.185)	(0.179)	(0.187)
Religion of head (base=Catholic)									
Anglican	1.088+	1.089+	1.034+	0.0130	0.0145	0.0252	-0.740**	-0.730**	-0.736**
	(0.0735)	(0.0648)	(0.0763)	(0.949)	(0.943)	(0.901)	(0.00405)	(0.00411)	(0.00410)
Other Christian	1.015	0.665	0.691	-0.258	-0.215	-0.209	-0.628	-0.553	-0.557
	(0.278)	(0.469)	(0.450)	(0.478)	(0.554)	(0.567)	(0.105)	(0.137)	(0.137)
Muslim	1.631*	1.592*	1.550*	0.00863	0.0192	0.0290	-0.529	-0.493	-0.499
	(0.0440)	(0.0251)	(0.0284)	(0.972)	(0.939)	(0.908)	(0.102)	(0.138)	(0.137)
Other	7.131**	7.024**	7.295**	-1.813**	-1.795**	-1.795**	-1.889**	-1.857**	-1.856**
	(1.89e-05)	(2.22e-05)	(1.89e-05)	(3.30e-08)	(5.37e-08)	(3.99e-08)	(0.00103)	(0.00134)	(0.00154)
HH shock experiences									
Natural shocks (floods, drought landslides)	0.426	0.641	0.565	-0.228	-0.255	-0.244	-0.317	-0.345	-0.350
	(0.457)	(0.246)	(0.307)	(0.226)	(0.173)	(0.192)	(0.162)	(0.125)	(0.120)
Crop pests and diseases	0.726	0.789	0.909+	-0.0825	-0.0772	-0.0944	-0.0952	-0.0932	-0.0846
	(0.211)	(0.143)	(0.0915)	(0.647)	(0.667)	(0.593)	(0.679)	(0.686)	(0.717)
Death of hh member	2.508+	1.959	2.023	-0.980**	-0.912**	-0.916**	-1.567**	-1.464**	-1.461**
	(0.0561)	(0.147)	(0.143)	(0.00691)	(0.00717)	(0.00736)	(0.00521)	(0.00583)	(0.00596)
Other	1.146+	1.243*	1.164*	-0.305	-0.327+	-0.317+	-0.609*	-0.622*	-0.628*
	(0.0617)	(0.0307)	(0.0367)	(0.127)	(0.0998)	(0.0976)	(0.0196)	(0.0178)	(0.0171)
hh livestock ownership (#)									
# livelarge animals	-1.182*	-1.183*	-1.125*	0.320*	0.316*	0.308+	0.309+	0.304+	0.308+
	(0.0128)	(0.0116)	(0.0159)	(0.0431)	(0.0457)	(0.0507)	(0.0826)	(0.0905)	(0.0905)
# livemedium animals	0.297	0.180	0.151	-0.0785	-0.0666	-0.0629	0.0527	0.0725	0.0704
	(0.229)	(0.456)	(0.532)	(0.309)	(0.398)	(0.433)	(0.664)	(0.556)	(0.571)
# live small animals	-0.00200	0.0616	0.0328	0.145*	0.138*	0.143*	-0.0705	-0.0843	-0.0866
	(0.994)	(0.812)	(0.890)	(0.0383)	(0.0489)	(0.0436)	(0.473)	(0.389)	(0.375)
Log of household asset value	-0.424**	-0.398**	-0.412**	0.225**	0.219**	0.221**	-0.0394	-0.0465	-0.0474
	(0)	(2.89e-10)	(0)	(3.40e-10)	(6.43e-10)	(4.03e-10)	(0.376)	(0.297)	(0.287)
Distance to district (miles)	0.0817*	0.0883**	0.0939**	-0.00127	-0.00158	-0.00218	-0.0268+	-0.0273+	-0.0270+
	(0.0169)	(0.00897)	(0.00564)	(0.901)	(0.877)	(0.832)	(0.0705)	(0.0635)	(0.0655)
Distance to market (miles)	-0.0232	-0.0306	-0.0379	0.0305+	0.0318+	0.0326+	-0.0355	-0.0332	-0.0337
	(0.693)	(0.603)	(0.530)	(0.0952)	(0.0838)	(0.0779)	(0.330)	(0.367)	(0.365)
# of food crops grown	-0.430*	-0.420*	-0.438**	-0.0237	-0.0259	-0.0252	0.115+	0.109+	0.109+

	(0.0189)	(0.0123)	(0.00906)	(0.616)	(0.588)	(0.601)	(0.0505)	(0.0637)	(0.0644)
Observations	975	974	974	974	973	973	975	974	974

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Appendix Table 4: Poisson model estimates on who decides how to allocate crop production harvested on this parcel? (e.g. whether to sell, consume etc) on household food security

	HFIAS			HDDS			MAHFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	mfx	mfx	mfx	mfx	mfx	mfx	mfx	mfx	mfx
Allocation of proceeds from plot									
Female head/ spouse		2.096	2.186		-0.296	-0.321		0.213	0.173
		(0.153)	(0.138)		(0.370)	(0.336)		(0.665)	(0.726)
Jointly husband and wife			0.504			-0.147			-0.259
			(0.490)			(0.517)			(0.373)
Sex of household head (1 if female)	0.688	-0.782	-0.774	0.118	0.320	0.320	-0.276	-0.426	-0.428
	(0.323)	(0.564)	(0.563)	(0.663)	(0.393)	(0.392)	(0.401)	(0.426)	(0.422)
Age of household head (yrs)	-0.0755**	-0.0808**	-0.0810**	-0.00106	-0.000387	-0.000498	0.0193*	0.0188*	0.0186*
		(0.000832)			(0.951)			(0.0232)	
Subregion (Base=Buganda)	(0.00236)		(0.000831)	(0.865)		(0.937)	(0.0183)		(0.0237)
Busoga	2.806**	2.740**	2.741**	0.553*	0.566*	0.567*	-0.690*	-0.703**	-0.702**
	(2.03e-06)	(2.85e-06)	(2.60e-06)	(0.0162)	(0.0144)	(0.0142)	(0.0113)	(0.00971)	(0.00956)
Bunyoyo	2.932**	2.846**	2.825**	-0.286	-0.276	-0.264	-0.353	-0.362	-0.341
	(7.09e-05)	(7.83e-05)	(9.21e-05)	(0.263)	(0.281)	(0.302)	(0.258)	(0.239)	(0.276)
Log share of cane land	2.473	2.668	2.720	0.194	0.157	0.142	-1.007	-0.986	-1.016
	(0.195)	(0.146)	(0.139)	(0.709)	(0.764)	(0.787)	(0.174)	(0.186)	(0.170)
Household equivalent (size)	0.604**	0.630**	0.629**	0.00373	0.00174	0.00340	-0.193**	-0.191**	-0.188**
	(5.59e-09)	(1.98e-10)	(1.64e-10)	(0.914)	(0.960)	(0.922)	(0.000251)	(0.000264)	(0.000359)
Log of annual income-salary	-0.102	-0.100	-0.104	0.00600	0.00596	0.00669	0.00142	0.00158	0.00277
	(0.185)	(0.183)	(0.169)	(0.744)	(0.745)	(0.712)	(0.957)	(0.953)	(0.915)
Log of annual income-wage	0.0834*	0.0802*	0.0770+	-0.00760	-0.00762	-0.00697	-0.0370	-0.0370	-0.0356
	(0.0385)	(0.0490)	(0.0610)	(0.649)	(0.648)	(0.675)	(0.106)	(0.106)	(0.123)
Maximum adult female education	-0.275**	-0.283**	-0.287**	0.0807**	0.0814**	0.0825**	0.0720**	0.0712**	0.0728**
	(0.000173)	(1.19e-05)	(8.58e-06)	(0.000627)	(0.000614)	(0.000539)	(0.00798)	(0.00854)	(0.00718)
Maximum adultmale education	-0.107+	-0.111*	-0.110*	0.0728**	0.0734**	0.0734**	0.0373	0.0371	0.0371
	(0.0530)	(0.0448)	(0.0458)	(0.00100)	(0.000955)	(0.000936)	(0.185)	(0.189)	(0.189)

Religion of head (base=Catholic)									
Anglican	1.088+	1.123+	1.115+	0.0130	0.00372	0.0102	-0.740**	-0.734**	-0.725**
	(0.0735)	(0.0676)	(0.0684)	(0.949)	(0.985)	(0.960)	(0.00405)	(0.00471)	(0.00520)
Other Christian	1.015	1.024	0.968	-0.258	-0.265	-0.245	-0.628	-0.625	-0.591
	(0.278)	(0.267)	(0.292)	(0.478)	(0.469)	(0.500)	(0.105)	(0.107)	(0.119)
Muslim	1.631*	1.718*	1.723*	0.00863	-0.00626	-0.00576	-0.529	-0.523	-0.523
	(0.0440)	(0.0269)	(0.0259)	(0.972)	(0.980)	(0.981)	(0.102)	(0.108)	(0.106)
Other	7.131**	6.958**	7.019**	-1.813**	-1.806**	-1.803**	-1.889**	-1.896**	-1.895**
	(1.89e-05)	(2.03e-05)	(1.95e-05)	(3.30e-08)	(4.14e-08)	(3.48e-08)	(0.00103)	(0.000968)	(0.000673)
HH shock experiences									
Natural shocks (floods, drought landslides)	0.426	0.465	0.444	-0.228	-0.237	-0.229	-0.317	-0.313	-0.301
	(0.457)	(0.406)	(0.428)	(0.226)	(0.207)	(0.222)	(0.162)	(0.170)	(0.186)
Crop pests and diseases	0.726	0.729	0.752	-0.0825	-0.0743	-0.0867	-0.0952	-0.0994	-0.119
	(0.211)	(0.186)	(0.170)	(0.647)	(0.681)	(0.631)	(0.679)	(0.668)	(0.608)
Death of hh member	2.508+	2.476+	2.477+	-0.980**	-0.980**	-0.973**	-1.567**	-1.567**	-1.552**
	(0.0561)	(0.0572)	(0.0616)	(0.00691)	(0.00737)	(0.00672)	(0.00521)	(0.00504)	(0.00434)
Other	1.146+	1.197*	1.204*	-0.305	-0.321	-0.325	-0.609*	-0.601*	-0.608*
	(0.0617)	(0.0443)	(0.0423)	(0.127)	(0.108)	(0.104)	(0.0196)	(0.0209)	(0.0188)
hh livestock ownership (#)									
# livelarge animals	-1.182*	-1.220*	-1.207*	0.320*	0.320*	0.317*	0.309+	0.310+	0.304+
	(0.0128)	(0.0107)	(0.0116)	(0.0431)	(0.0437)	(0.0454)	(0.0826)	(0.0832)	(0.0893)
# livemedium animals	0.297	0.230	0.223	-0.0785	-0.0714	-0.0685	0.0527	0.0468	0.0519
	(0.229)	(0.339)	(0.357)	(0.309)	(0.360)	(0.387)	(0.664)	(0.703)	(0.675)
# live small animals	-0.00200	0.0113	-0.00847	0.145*	0.144*	0.150*	-0.0705	-0.0694	-0.0608
	(0.994)	(0.966)	(0.974)	(0.0383)	(0.0391)	(0.0327)	(0.473)	(0.482)	(0.529)
Log of household asset value	-0.424**	-0.408**	-0.409**	0.225**	0.222**	0.222**	-0.0394	-0.0373	-0.0368
	(0)	(1.15e-10)	(6.95e-11)	(3.40e-10)	(4.83e-10)	(4.60e-10)	(0.376)	(0.395)	(0.399)
Distance to district (miles)	0.0817*	0.0851*	0.0856*	-0.00127	-0.00145	-0.00164	-0.0268+	-0.0266+	-0.0269+
	(0.0169)	(0.0139)	(0.0143)	(0.901)	(0.888)	(0.874)	(0.0705)	(0.0697)	(0.0654)
Distance to market (miles)	-0.0232	-0.0287	-0.0347	0.0305+	0.0312+	0.0324+	-0.0355	-0.0361	-0.0340
	(0.693)	(0.630)	(0.574)	(0.0952)	(0.0885)	(0.0769)	(0.330)	(0.321)	(0.362)
# of food crops grown	-0.430*	-0.442*	-0.450*	-0.0237	-0.0220	-0.0209	0.115+	0.114+	0.116*
	(0.0189)	(0.0123)	(0.0113)	(0.616)	(0.646)	(0.663)	(0.0505)	(0.0527)	(0.0461)
Observations	975	974	974	974	973	973	975	974	974

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

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