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Sugarcane Production and Food Security in Uganda

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ABSTRACT

This study investigates the relationship between farm household participation in sugarcane production and food security in the main sugarcane-producing sub-regions of Busoga, Buganda, and Bunyoro of Uganda. Analysis is based on primary data collected from 1,771 households in these regions as well as qualitative focus group discussions with cane growers. Descriptive analysis found that 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); revealed higher average values of HFIAS, MAHFP and HDDS for cane growing households compared to non-cane growers. Poisson regressions of the three food security measures (and an Ordered Probit Model of Food Insecurity Score, 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. Maintaining the positive association between cane production and food security requires a policy environment and public sector governance to promote improved coordination between growers and millers and consideration of related income stabilisation mechanisms for sugarcane farmers. In addition, extension services should promote sugarcane production on farms with 8 or more acres only, farmer adherence to maintaining food crop cultivation, and use of productivity-enhancing technologies in cane and food crop production.

Keywords: Crop productivity, market participation, agricultural technology, smallholder farmers

JEL Classifications: Q00, Q10, Q13, Q12

EXECUTIVE SUMMARY

The government of Uganda has supported policies over the past 20 years intended to facilitate the growth of its sugarcane industry (Mbowa et al, 2023) given that sugarcane is high-value crop that can improve growers' farm income and thus improve their food security. The sugarcane industry of Uganda has subsequently grown rapidly the past 20 years, as sugarcane production increased from 1.5 million MT in 2000 to 5.8 million MT 2020 (Mbowa et al, 2023), driven primarily by a four-fold expansion in cane area during that period (FAOSTAT, 2021). However, recent evidence from the three main sugarcane-growing areas of Uganda indicates that food insecurity and income poverty there have increased in recent years, relative to other regions of the country (UBOS 2021). Citing this evidence and anecdotal information, some have claimed that sugarcane cultivation is contributing to or driving the recent increase in food insecurity in cane growing areas (Mwavu et al., 2018). Yet, within the context of Uganda, there is no empirical evidence (to our knowledge) that uses large-scale household survey data to compare the food security status of cane producers and non-producers in the main cane growing regions of Uganda. Neither has there been research to assess whether the recent increase in food insecurity in these areas could be plausibly attributed to cane production or not.

This study investigates the relationship between farm household participation in sugarcane production and household food security in the main sugarcane-producing sub-regions of Busoga, Buganda, and Bunyoro of Uganda. 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? Descriptive and econometric analysis is used to investigate the relationship between sugarcane production and household food securing, using primary data collected from 1,771 households in these regions in November/December 2021 as well as qualitative focus group discussions with cane growers.

Using three different measures of food security -- Household Food Insecurity Access Score (HFIAS); Months of Adequate Household Food Provisioning (MAHFP), and the Household Dietary Diversity Score (HDDS), descriptive analysis shows that cane growing households had higher average values of each measure as compared with non-cane growers. Econometric analysis finds that sugarcane growing households were 17 percent less food insecure, on average, relative to non-cane growers, as measured by the 27-point Household Food Insecurity Access Scale (HFIAS) – while controlling for a variety of household and community-level factors known to influence household food security. Cane growing was also associated with one additional month of adequate household food provision (MAHFP), an improvement of 10 percent compared with non-cane growers. No significant association was found between cane production and HDDS, a 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 was 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. 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. Results of testing whether a household female head/spouse has strong influence in intra-household decision making on crop choice or crop marketing show that is no evidence to support the expectation that a household with a female head or spouse with strong influence on crop choice or crop marketing.

Policy recommendations

Policy reform and active public sector oversight of the sugarcane industry is within the mandates of the Ministry of Agriculture and the Ministry of Industry, Trade, and Commerce, and they must coordinate with each other and sector stakeholders to improve coordination between growers and millers. Following a difficult period of poor grower-miller coordination from 2018 to 2021 and a crash in 2021, regaining and maintaining the benefits of cane production for food security requires reforms to the industry's policy environment and public sector governance (Mbowa et al, 2023). Reforms are needed to promote improved coordination between growers and millers and consideration of related income stabilisation mechanisms for sugarcane farmers. In addition, extension services should promote sugarcane production on farms with 8 or more acres only, farmer adherence to maintaining food crop cultivation, and use of productivity-enhancing technologies in cane and food crop production.

There are several ways in which Ugandan policy makers can help to maintain the income and food security benefits of sugarcane growing in the country. First, Ministry of Trade, Industry and Cooperatives (MTIC) and the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) should provide a policy environment and public sector oversight of institutional arrangements between millers and growers that promote higher cane productivity and profitability for growers and more reliable market assurance for both growers and millers. Such arrangements would facilitate stronger coordination of local cane supply and demand, grower access to improved inputs, market assurance for both growers and millers, and a transparent and fair process for millers and grower association representatives to negotiate a cane purchase price each season, based upon a set formula (Mbowa et al, 2023). This level of coordination and oversight can only be achieved if MTIC and

MAAIF take a more active role in governance and oversight of the cane industry and grower-miller relations (ibid, 2023).

Second, MAAIF extension services should promote sugarcane production on farms of no more than 8 acres, the adherence of cane growers to maintaining at least part of their cultivated area in food crops, and the adoption of productivity-enhancing crop technologies by cane producers for both cane and food crops. Productivity improvements in both cane and food crops in cane growing regions are vital to enable farm households to improve both their household incomes and food security.

TABLE OF CONTENTS

Contents

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

ATC	Average Treatment Effects on the Control
ATE	Average Treatment Effects
ATT	Average Treatment Effects on the Treated
COC	Cost of Calorie function
DIA	Dietary Intake Assessment
EIU	Economist Intelligence Unit
EPRC	Economic Policy Research Center (Uganda)
FAO	Food and Agriculture Organization of the United Nations
FCS	Food Consumption Score
FGD	Focus Group Discussion
FIES	Food Insecurity Experiences Scale
GDP	Gross Domestic Product
GFSI	Global Food Security Index
HCES	Household Consumption and Expenditure Score
HDDS	Household Dietary Diversity Score
HDI	Human Development Indicators
HFIAS	Household Food Insecurity Access Score
HFSS	Household Food Security Scale
HHS	Household Hunger Scale
IPW	Inverse Probability Weighting
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries (Uganda)
MAHFP	Months of Adequate Household Food Provisions
MTIC	Ministry of Trade, Industry and Cooperative (Uganda)
NNM	Nearest Neighbor Matching
PRCI	Feed the Future Innovation Lab for Food Security Research, Capacity, and Influence
PSM	Probability Score Matching
SDG	Sustainable Development Goals
UN	United Nations
UNDP	United Nations Development Programme
USDA	United States Department of Agriculture

I. Introduction

The government of Uganda has supported policies over the past 20 years intended to facilitate the growth of its sugarcane industry (Mbowa et al, 2023) given that sugarcane is high-value crop that can improve growers' farm income and thus improve their food security. Participation in cane outgrower schemes can also improve grower access to yield-enhancing crop production technologies and management practices (Hess et al., 2016), which can improve farm productivity beyond cane and facilitate rural economic development (Burnod et al., 2015; Hall, 2017; Zaehringer, 2018 (a &b). The GoU also sees sugarcane as a key agroindustry that can help generate rural farm on non-farm employment, higher farm incomes and improve rural infrastructure (Fitawek and Hendriks, 2021). There is also evidence that crop diversification can enhance food security and dietary diversity, particularly when the level of production diversity in an area 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).

The sugarcane industry of Uganda has grown significantly in the past 20 years, as sugarcane production increased from 1.5 million MT in 2000 to 5.8 million MT 2020 (Mbowa et al, 2023). This expansion was driven almost entirely by an increase in area cultivated to cane from 20,000 ha in 2000 to over 81,000 ha in 2020 (FAOSTAT, 2021). However, recent evidence from the three main sugarcane-growing areas of Uganda indicates that food insecurity and income poverty there have increased in recent years, relative to other regions of the country (UBOS 2021). Citing this evidence and anecdotal information, some have claimed that sugarcane cultivation is contributing to or driving the recent increase in food insecurity in cane growing areas (Mwavu et al., 2018). Related concerns have been raised about sugarcane in other countries, noting that large scale sugarcane farmers and milling companies desiring to expand nucleus farms may acquire large pieces of land from communities and lead to adverse spillovers effects on local communities' food security (Aabø and Kring,2012; Fitawek and Hendriks, 2021; Lisk, 2013; Herrmann, 2017; Nolte and Ostermeier, 2017). In addition, Adams et al. (2019) note that contract farming in sugarcane production can exacerbate gender inequality in terms of access to land, intra-household labour allocation and participation in production and marketing decisions. Resulting intra-household decisions may directly or indirectly affect household food security and nutrition given women's important roles in agricultural production and domestic decisions around food sourcing and preparation. However, within the context of Uganda, there is no empirical evidence (to our knowledge) that uses large-scale household survey data to compare the food security status of cane producers and non-producers in the main cane growing regions of Uganda. Neither has there been research to assess whether the recent increase in food insecurity in these areas could be plausibly attributed to cane production or not.

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*), the findings from them on this relationship are mixed. 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 fill this evidence gap for Uganda 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, and to a much smaller one on the relationship between sugarcane production and household food security.

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? 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 outcome, all else constant.

This study is based on primary data collected from 1,771 cane growing and non-growing households in these regions in November/December 2021 as well as qualitative focus group discussions with cane growers and key informant interviews with large and small cane mills, cane grower associations, and relevant government officials. The study addresses the three research questions and tests the three hypotheses through descriptive and econometric analysis of this household survey data.

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.

II. Literature Review

Effects of growing sugarcane on household food security

This section provides review of literature on the relationship between sugarcane production and household food security, as this is needed to guide the analytical strategy for the paper, including the specification of multivariate regressions of different measures of 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 quesiton of whether smallholder participation in contract farming (CF) arrangements results in positive or negative changes in household welfare in practice. An extensive review of literature by Otsuka, Nakano & 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 the 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) claim 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 being shifted from food crops into 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. 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 percent 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 percent of households were food secure while 49.7 percent 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.

Several papers have discussed the growing competition between sugarcane and food crops on land use that is threatening world food production and consequently, food security. Other social and environmental impacts include the harmful impact on biodiversity and negative environmental externalities such as air and water quality and quantity, pollution, all of which affect food utilization, another pillar of food security. Notably, given that agrobiodiversity forms the basis for sustained household food production and food security, the commercial monoculture of sugarcane cultivation in Eastern Uganda impedes possible advancements in food security for the region (Mwavu et al.,

2016). Therefore, the loss of biodiversity threatens agricultural production and food security and practices that conserve, sustainably use natural resources and enhance biodiversity are necessary at all levels in farming systems as they important for food production, livelihood security, health and the maintenance of ecosystems (Thrupp, 2000).

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 food security measures of 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. In addition, 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) used analysis of a computable general equilibrium model and concluded 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.

By contrast, cane outgrowers in Zambia have access to better water facilities, electricity, and more income earnings than non-participants, and 74 percent of cane growers were food secure compared with 47 percent of non-growers (Bubala et al. (2018). On other hand, cane growers have more debt compared to the non-cane growers. 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. The stark differences across studies in the relationship between participation in cane production and household food security raises important questions about whether differences in institutional arrangements and other local factors condition this relationship.

Gendered effects of sugarcane production and food security

Integration of smallholders in outgrower cane schemes has been advanced as a strategy for poverty reduction, but outgrower cane farmers are not homogenous (Hall et al., 2015). They have distinct resource endowments in terms of land control, labour conditions, financial resources and social resources which shape their participation in cane production. In addition, women experience a gender gap with respect to access to productive assets, like land; agricultural inputs, family labour; and services such as credit and extension, which together can result in women having lower crop productivity. These gender inequalities are underpinned by harmful gender norms which restrict women's livelihood roles and economic opportunities within agrifood systems. Women in most Sub-Saharan countries predominantly participate in nonfarm activities such as small-scale trading 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). (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.

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 percent 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. For this study, we explore whether final decision on what to plant on a parcel and harvested crop allocations/decisions by gender matter for food security.

III. 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.

Description of study areas

Sugarcane production in the sub-regions of Buganda[1], Busoga[2] and Bunyoro[3] 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 percent of GDP (UBOS 2022) and employs over 70 percent 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.

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[4], registered and not aided, and unregistered and unaided

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

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

[3] Bunyoro subregion districts include: Buliisa, Hoima, Kibaale, Kiryandongo, Masindi, Kikuube, Hoima City, Kitagwenda

[4] 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

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.

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.

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.

Measuring household food security

Food security is a complex issue that cannot be measured by one indicator alone, which explains why a large number of food security measures have been developed, though each have their own strengths and weaknesses (Manikas et al., 2023; Kolog et al., 2023; Becquey et al, 2010). In this analysis, we used the definition of food security from the Food and Agriculture Organization of the

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.

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. The food items in Uganda commonly consumed within each food group are shown in Appendix Table A1.

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

Indicator	Recall period	Description	Source
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
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.

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

To assess the utilisation dimension, we used the household dietary diversity score (HDDS), which counts the number of different food groups the household consumed up to a maximum of 12 food groups (Swindale and Bilinsky, 2006). It is based on survey respondent estimates of household consumption during the past 7 days. HDDS was designed to serve as an indicator of food access (Swindale and Bilinsky, 2006), yet in some cases has been found to be 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 digestive system. We do not account for this variable as our data did not collect it.

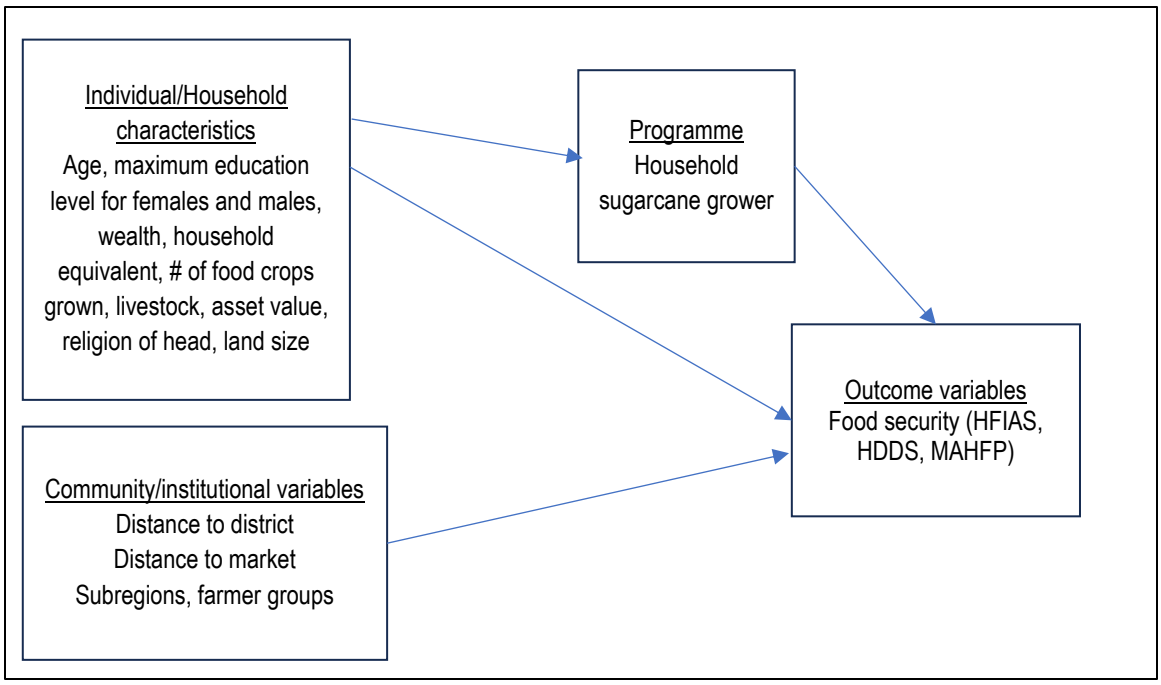
The month of adequate household good provisioning (MAHFP) indicator was used to *assess the stability* dimension of food security because the MAHFP reflects the stability of a minimum food supply throughout the year (Bilinsky and Swindale, 2010; Coates, 2013). The MAHFP counts the number of months in 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.

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, 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 cane sales 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.

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



Source: Authors won conceptualisation, 2023

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:

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

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 $E(y|x_k)$. 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:

$$\log\left[E(y|x_1, x_2, ..., x_k)\right] = \beta_0 + \beta_1 x_1 + ... + \beta_k x_k; \qquad y|x_k \square P(\theta) \tag{2a}$$

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

$$E(y|x_1, x_2, ..., x_k) = \exp(\beta_0 + \beta_1 x_1 + ... + \beta_k x_k) \tag{3a}$$

$$\mu = E(y|x_k) = Var(y|x_k) = \exp(\beta_0 + \beta^T x) \tag{4a}$$

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

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

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:

$$g(y) = \log\left[E(y|x_k)\right] = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k + u_i, \tag{6a}$$

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.

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

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;

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

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;

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

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

$$\Pr ob[Y_i = j] = \Pr ob\left[\mu_{j-1} < y_i^* \le \mu_j\right]$$
$$= \Pr ob\left[\mu_{j-1} - x_i'\beta < e_i \le \mu_j - x_i'\beta\right]$$
$$= \Phi\left(\mu_j - x_i'\beta\right) - \Phi\left(\mu_{j-1} - x_i'\beta\right) \qquad (3b)$$

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

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

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

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

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

The dependent variable, given as FS is the household's food security status proxied by HFIAS. i characterizes the i th 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 analyze 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:

$$\chi^2=\sum_k^r\sum_j^c\frac{\left(O_{kj}-E_{kj}\right)^2}{E_{kj}} \text{ and } E_{kj}=\frac{R_kC_j}{n} \qquad (6b)$$

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

n - total number of households

To analyze 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.

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

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 gathered gender-differentiated information on land ownership and decision making at the plot level, for all plots. For example, for each plot, the survey asked, "who makes the final decision on what to plant on the parcel?" and 'Who decides how to allocate crop production harvested on this parcel? e.g. whether to sell, consume etc)? 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. These are mutually exclusive categories.

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

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.

IV. Results and analysis

In this section, first we examine the social-economic characteristics of the cane and non-cane growing households in the survey sample, the institutional and community characteristics of villages in which they reside, and food security status of cane and non-cane growing households. We then analyze the relationship between the various food security indicators and participation in sugarcane production. Finally, we Poisson and ordered Probit regressions to assess various specifications of factors associated with household food security and then address the key questions and hypotheses to be tested.

Social-economic and institutional characteristics

We next compare socioeconomic characteristics of cane growers and non-growers to see if there are any systematic differences between them. The average age of household heads in the sample was 48 years for both groups (Table 2), though cane growers were more likely to be male headed (9 out of 10) compared to 7 out of 10 among non-cane growers. Average family size is slightly larger for cane growers. About 46% and 49% of the cane and non-cane grower households' heads, respectively, were employed for salary or wage. On average, cane growers had about 7 times more land than the non-cane growers, and cane growers are more educated and likely to be literate. In addition, maximum adult (18+) female education in the household was 8.3 years while for non-cane growers had 7 years. Cane growers have considerably more asset wealth, as the average value of their household assets is over three times that of non-growers (Ugx3.3m vs Ugx0.92 million respectively). Among cane growers, decisions on how to allocate crop production harvested such as sell or consume are primarily made by the male head (49%) with fewer decisions made by the female head/spouse or jointly done. Non-grower households are less likely to have a male head or spouse (40 percent) make decisions about the allocation of crop sales income allocation decisions. In short, patriarchy is more entrenched in cane grower households.

Table 2. Socioeconomic characteristics of sample households

Select indicators	All (1)	Cane Producers (2)	Non-Cane Producers (3)	Diff (p-value) (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
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
Other members and mixed allocation	0.19	0.23	0.16	0.001
N	1,771	983	788	

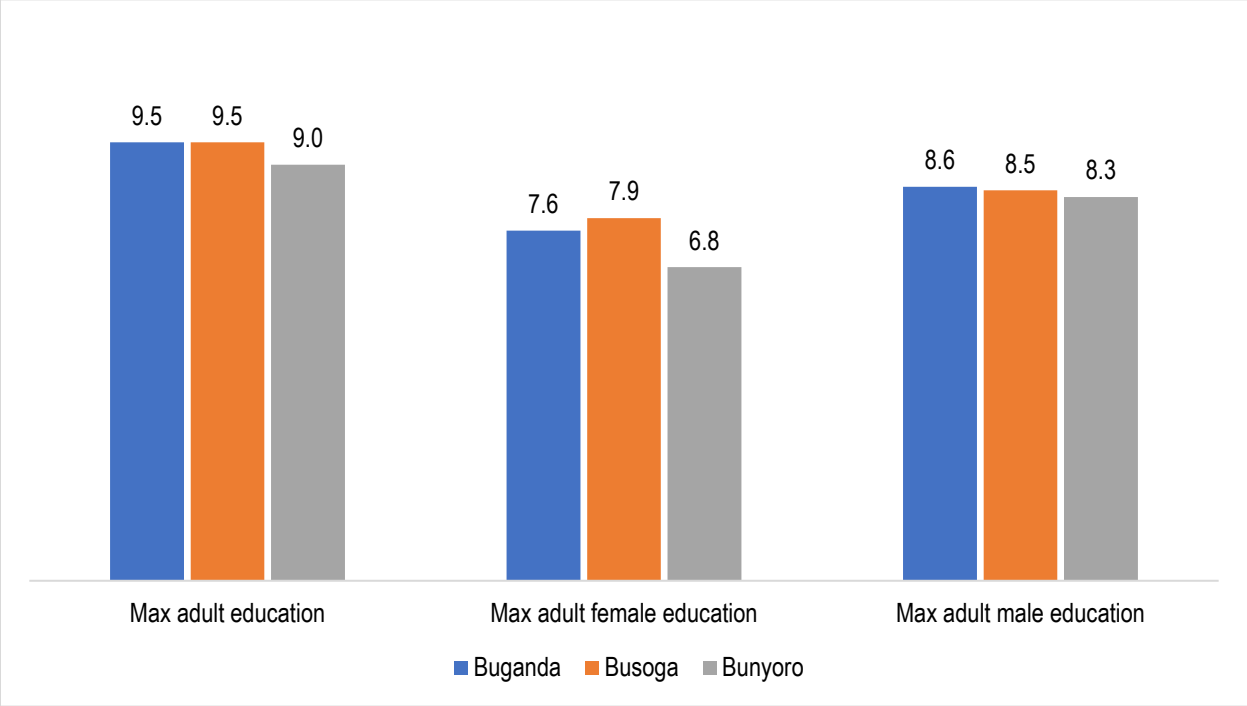
Notes: * Annual household income =Annual salary income + wage income

* Off-farm employment=Salaried/wage earner/own business

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

Give 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, 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.

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



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

On average, both cane and non-cane growers cultivate 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 by cane production status in distance to districts or food markets, though minor differences in household shocks for disease and pests and income related shocks.

Table 3. Household access to markets and services, shocks, and community-level characteristics of cane growers and non-growers

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

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. 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.

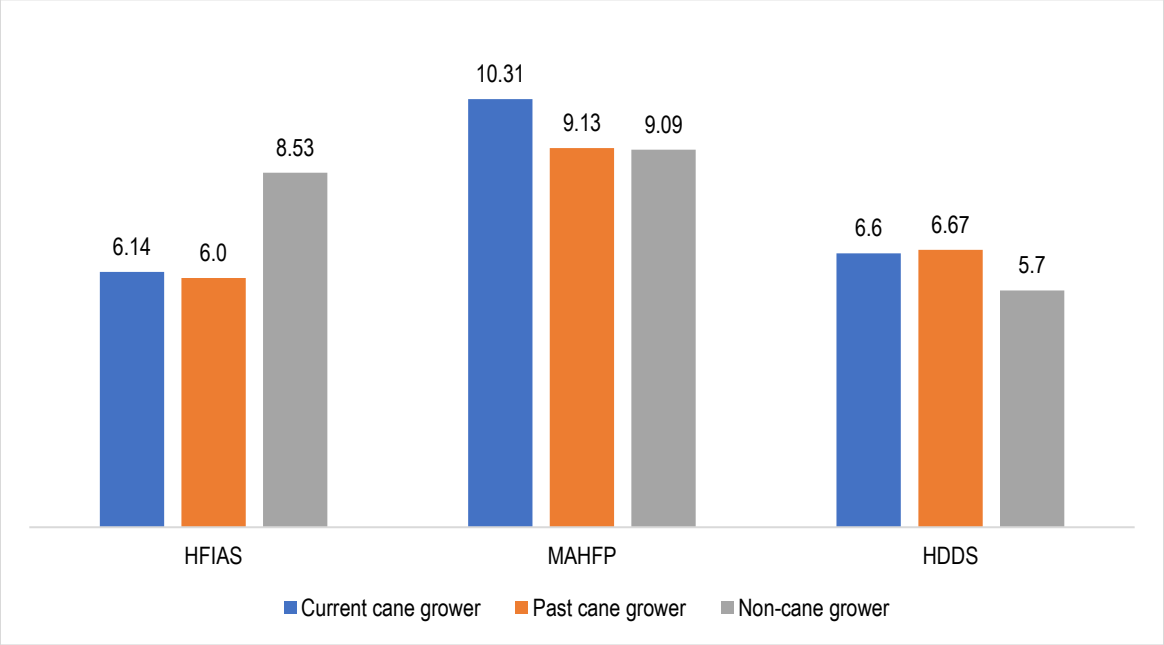
Table 4. Summary statistics of food security indicators by cane status, December 2020-November 2021

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

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 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 (grey bars in 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.

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

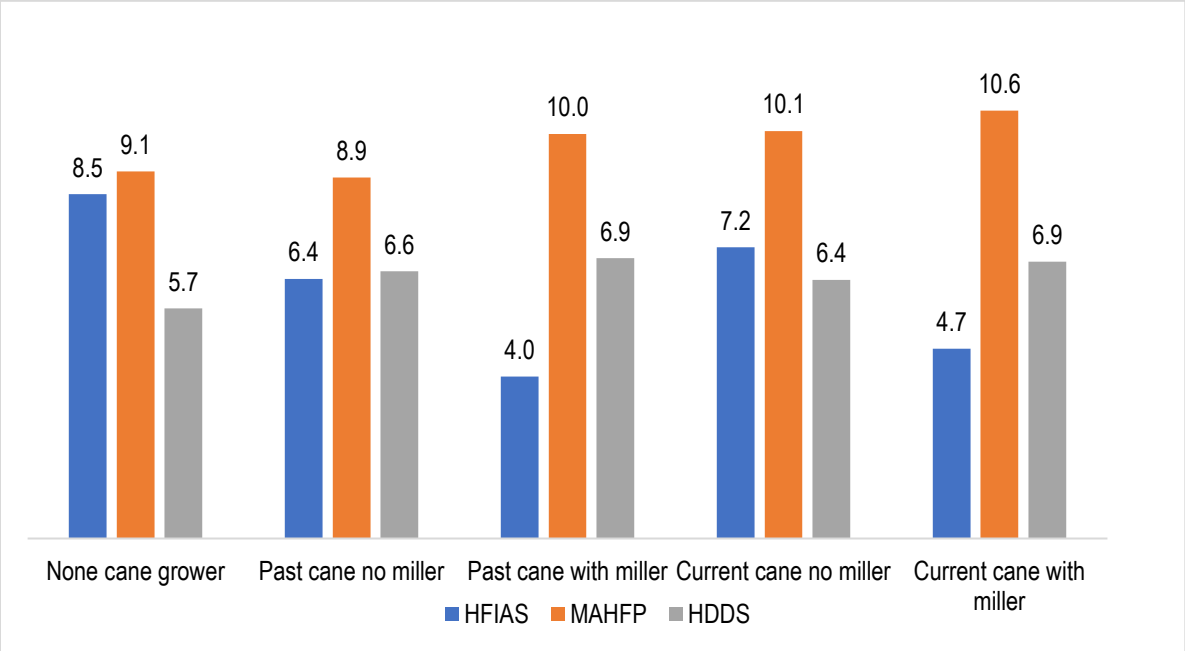


Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

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 their "with" or "without "miller status refers to their relationship (or not) with a mill in the last year that they grew cane.

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.

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



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

Does food security differ by cane growing status?

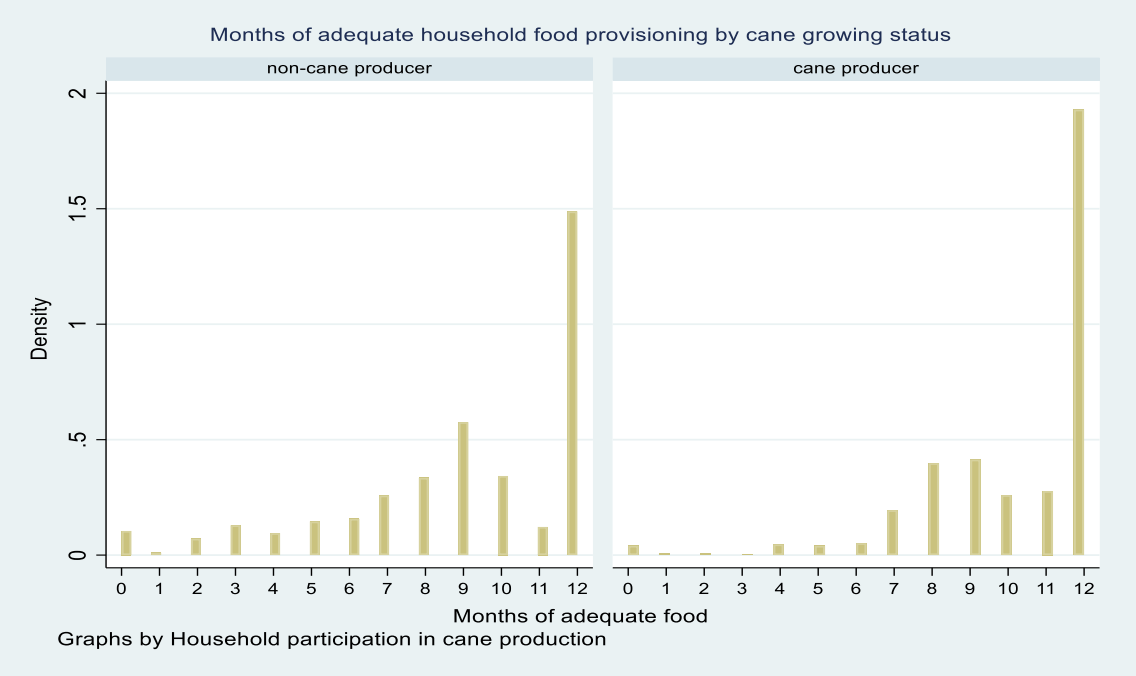
More cane growing households indicated in December 2021 that they had had adequate food provision over the prior 12 months as compared with non-cane households. In addition, a histogram of MAHFP, which shows the density of this variable, shows visually that current cane growers are more likely to have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

Figure 6 further shows that about 24 percent 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

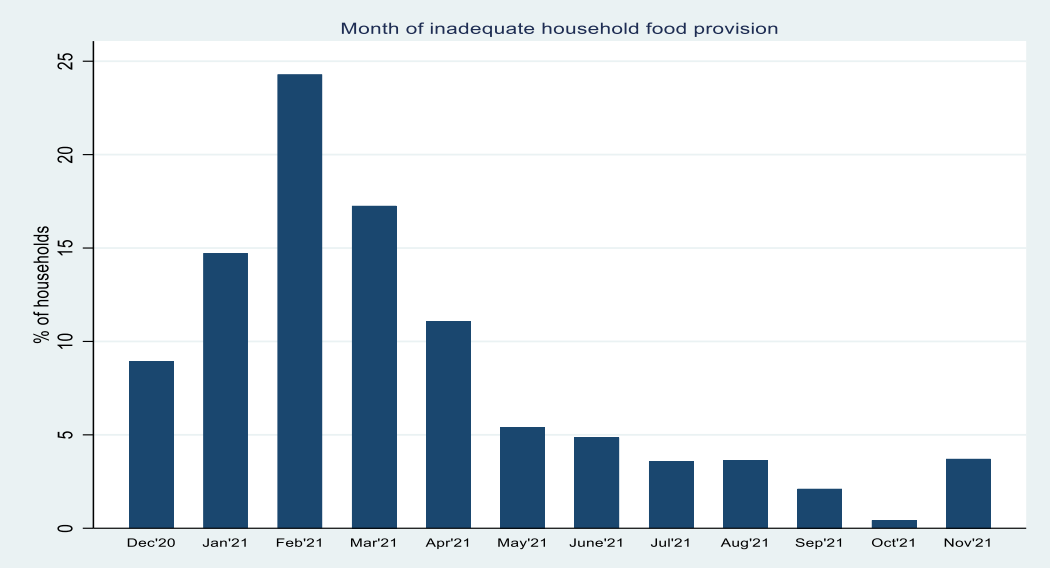
cane around August to October 2021 and income from cane had started to dwindle hence observed increase in inadequate food provisions in November as cane markets were sticky.

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



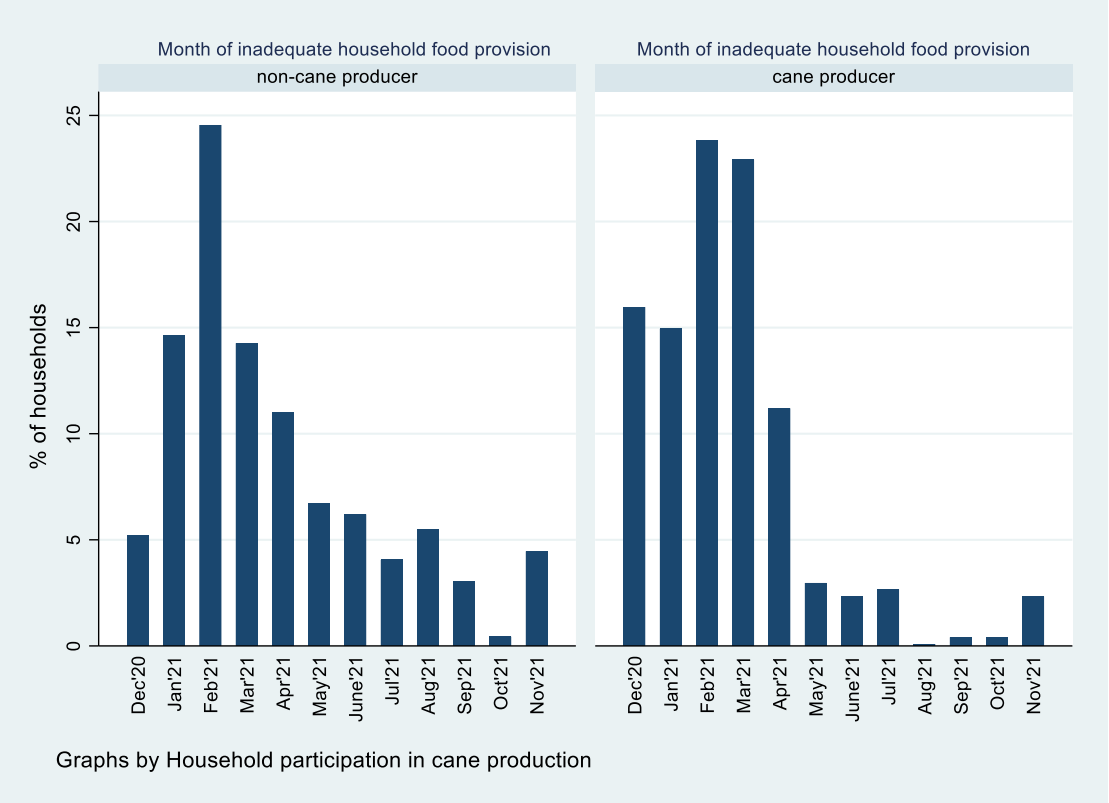
Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

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. Shares of households by reported months of inadequate household food provision, by cane grower status (%), 2021

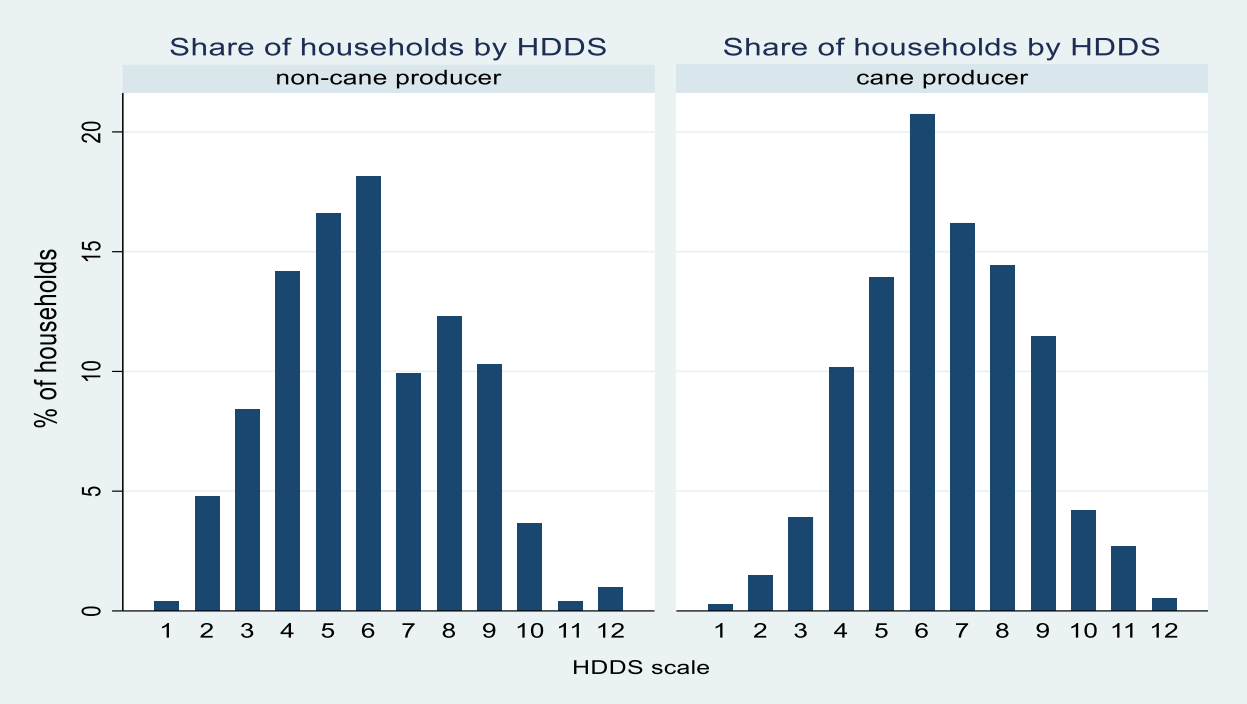


Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Histograms of HDDS shown in Figure 9 show the distribution of HDDS values for cane growers and non-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.

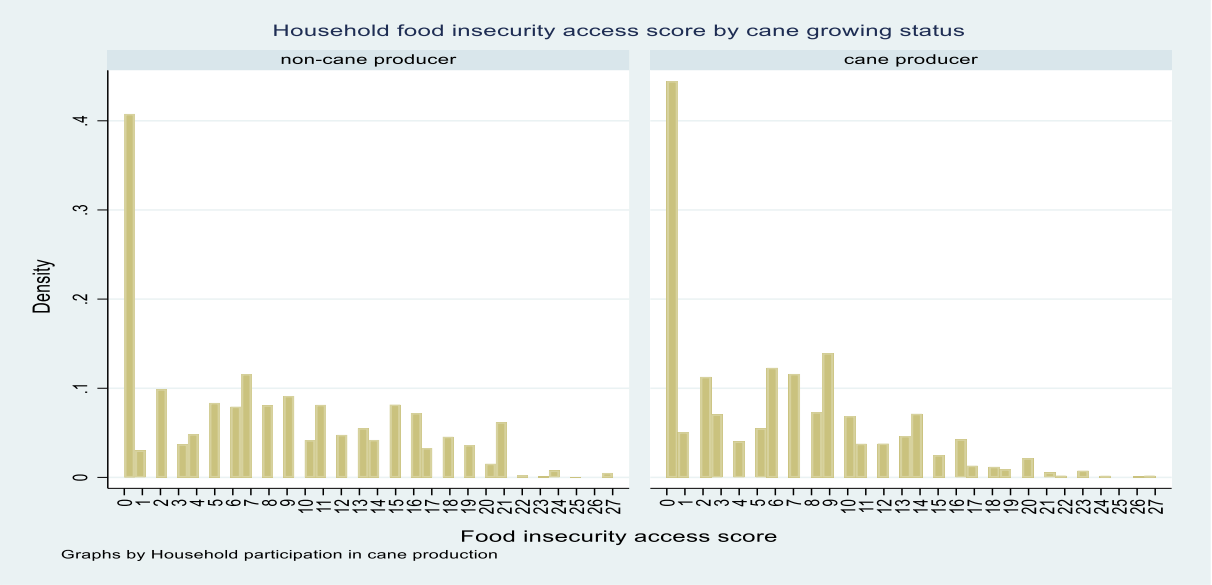
Similarly, histograms of the HFIAS scores in Figure 10 show the distribution of HFIAS among cane growers and non-growers across the variable's range from 0-27. The higher the score the more food insecure a household is with respect to accessing its required food needs. The large density around zero indicates a significant share of farmers that indicated having no aspects of household food insecurity within the past week.

Figure 8. Share of households by Household Dietary Diversity Score (HDDS) (%), 2021



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

Figure 9. Share of households by household food insecurity access score and cane growing status (%)

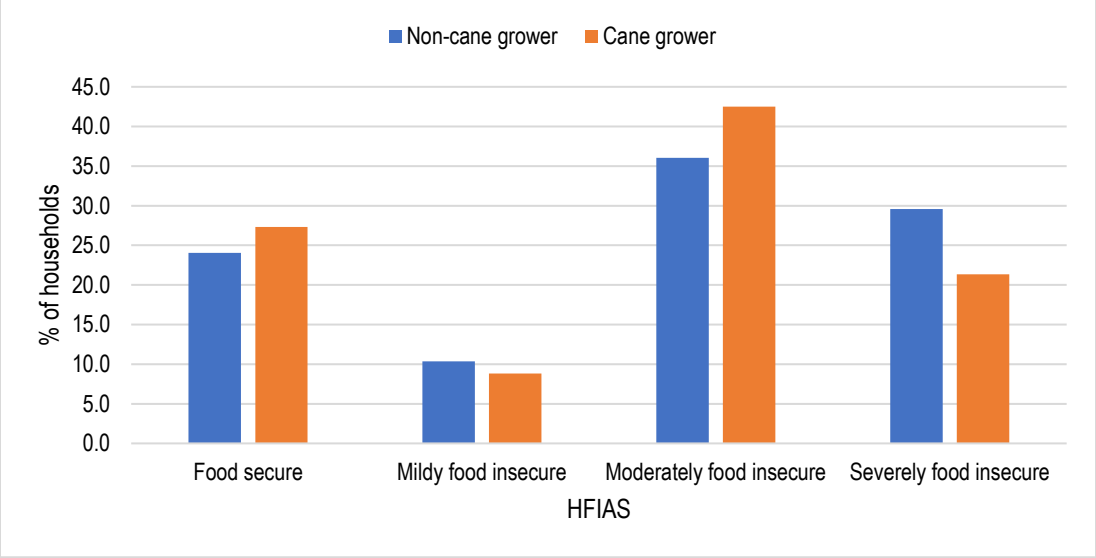


Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

Based on the HFIAS, approximately 3 of every 10 cane growers were classified as being "severely food insecure" in the past 30 days, 6 of 10 "moderately food insecure"; 2 of 10 were "Mildly food

insecure" and 4 in ten were "food secure" (Figure 11). A similar pattern is observed for non-cane growers yet they are more likely to be severely food insecure (30 percent) than cane growers (21 percent) (Table 6). 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 (33%) compared with female headed non-grower household (41%). A similar pattern is seen for male headed cane and non-cane growing households

Figure 10. Household food insecurity access scale by cane growing status



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

Table 5. Share of households by food insecurity access scale and grower-miller arrangement (%), 2021

Food security scale	Non-cane grower	Past cane no miller	Past cane with miller	Current cane no miller	Current cane with miller	Total
Food secure	21.1	27.8	50.8	20.0	37.2	25.4
Mildly food insecure	7.7	19.4	8.6	6.5	11.9	9.7
Moderately food insecure	37.3	32.8	32.3	45.6	38.5	38.7
Severely food insecure	33.9	20.1	8.3	27.9	12.5	26.2
Total	100	100	100	100	100	100

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

Not surprisingly, food insecurity has a strong negative relationship with household total landholding, as the mean and median of landholding declines significantly as one moves from the sample of food secure households (mean landholding of (12.8 acres) to those that are mildly food secure (7.8), then

from mildly (7.8) to moderately food insecure (6.9), and again from moderately to severely food insecure (3.8) (Table 7). It is also clear that current cane growers have much higher mean and median landholding (14.8 and 6.6 acres, respectively) than both past (3.5 and 2 acres) and "never" cane growers (2.5 and 1.75 acres). Because past cane growers have better mean and median food security levels than never cane growers (Figure 4) yet similar median landholding, this suggests that past cane growers likely have access to relatively high return non-farm sources of income, which may help explain why their food security status is better than that of never cane growers.

Table 6. Mean and median household landholding by household food insecurity access scale and cane growing status

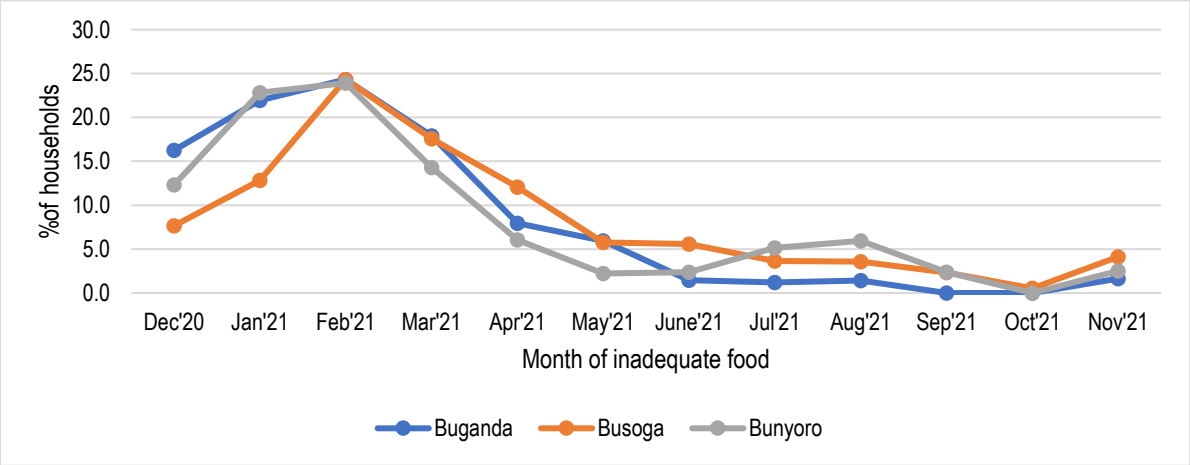
	All		Current cane grower		Past-cane grower		"Never a cane grower"	
HFIAS-scale	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Food secure	12.78	3.60	25.69	9.50	2.72	1.55	2.79	2.00
Mildly food insecure	7.84	5.00	15.41	10.00	3.37	2.50	3.46	1.50
Moderately food secure	6.93	4.00	11.25	6.57	4.66	5.00	3.05	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

Sub regional heterogenity in food security outcomes 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 percent of households from June until November. 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 12. Percentage of households by month of inadequate household food provision, %



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

Farm households in Buganda are more likely to be food secure (41 percent) than those in Busoga (23.8) or Bunyoro (15 percent) (Table 7). 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 percent of households in Busoga were moderately or severely food insecure compared with 65 percent in Bunyoro yet only 44 percent in Buganda. This is likely due to the fact that Bugandan households in our sample have considerably more asset wealth than the other regions. In fact, median Bugandan total household value of assets per 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/AEAE). This is likely explained by the fact that rural 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 in Dec 2021 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 7. Share of households by HFIAS scale value, cane growing status, and region (%)

HFIAS scale	Current cane grower	Past cane grower	Non-cane grower	Total
All	*Column %*	*Column %*	*Column %*	*Col. %*
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
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

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 percent are from the lowest (first) asset wealth quintile compared with 33.7 percent in the top (fifth) quintile (Table 8, upper panel). Likewise, 42.6 percent of households categorized as severely food insecure are in the lowest quintile compared with only 6.8 percent 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 percent 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 percent of households in the top wealth quintile reported moderate to severe food insecurity during the month prior to interview in Dec 2021.

Table 8. Household food insecurity access scale by quintiles of total household asset value per AE

Quintiles of total HH asset value/AE	Food secure	Mildly food insecure	Moder-ately food insecure	Severely food insecure	Total
	------- share of households by column (%) -------				
1-low	7.6	4.3	16.8	42.6	20.0
2	15.1	15.1	25.6	18.2	20.0
3	22.8	24.4	15.0	23.6	20.1
4	20.8	39.4	23.4	8.8	20.5
5-high	33.7	16.8	19.3	6.8	19.4
Total	100	100	100	100	100
	------- share of households by row (%) -------				
1-low	9.7	2.1	32.4	55.8	100.0
2	19.2	7.4	49.5	23.9	100.0
3	28.7	11.8	28.7	30.7	100.0
4	25.8	18.7	44.2	11.3	100.0
5-high	44.0	8.4	38.4	9.2	100.0
Total	25.4	9.7	38.7	26.2	100.0

Source: Authors' computations from EPRC sugarcane grower survey data

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

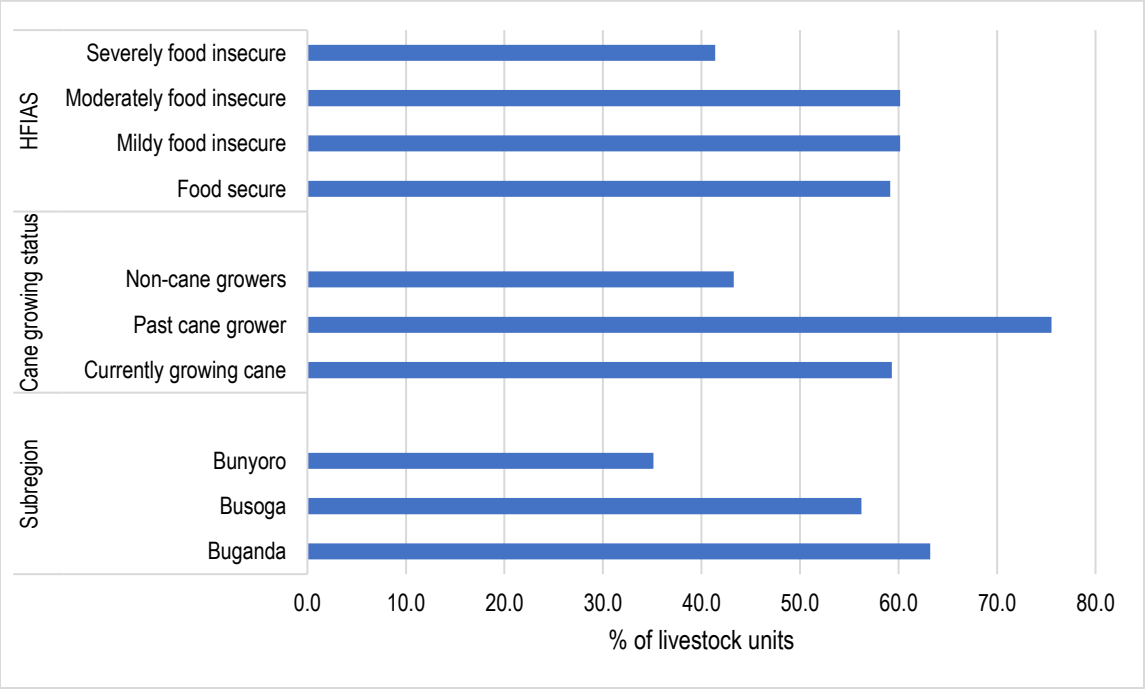
> **"…**Sugarcane growing itself has no problem for farmers who have enough land. They have managed to grow sugarcane and utilize some land for growing food crops. The family doesn't lack food since you plant 3-4acres of food crops out of the 10 acres and the other 6 for sugarcane growing (by Male FGD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

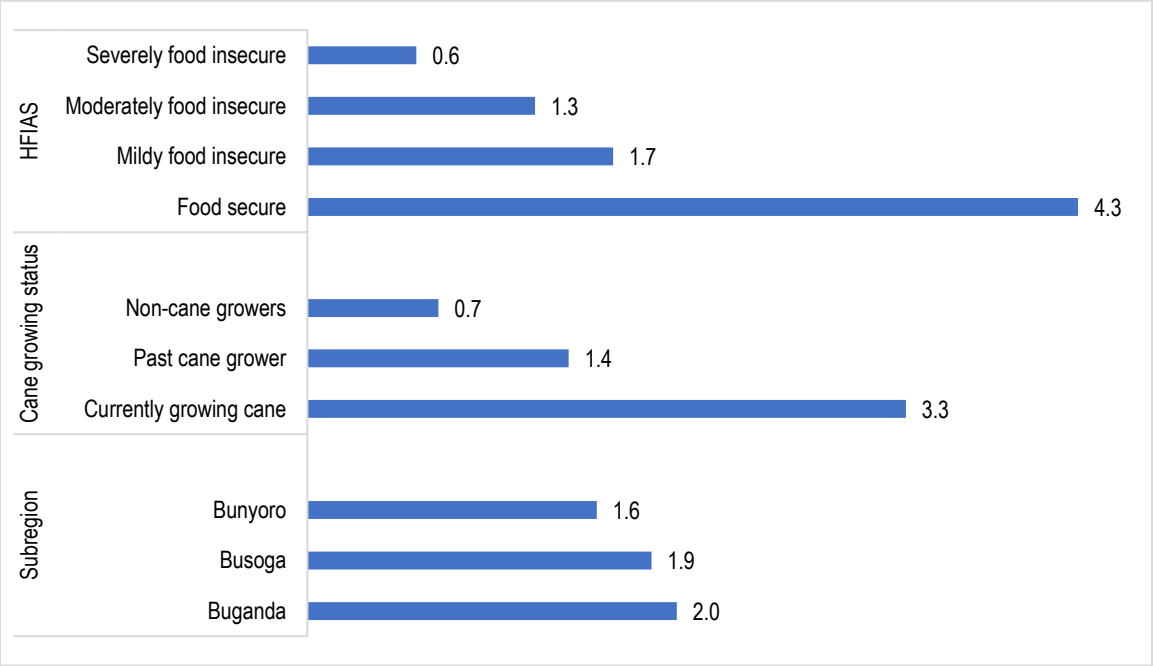
In looking at specific wealth indicators such as household ownership of livestock (Figure 11) and value of assets (Figure 12) by HFIAS, cane growing status and subregion levels. For instance, we note that Buganda followed by and past cane growers and food seuecure and midley food insecure houdholds owenered a higher share of ltropical livestock than in Bunoro, non cane growing and severely foo insecure houeholdshad more live animals (Figure 11). Food secure, current cane growers and those in Buganda sub regions had household assets of much higher value (Figure 12).

Figure 11. 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 12. Total household value of assets by by subrgeion, cane growing status and food securty status, Ugx (million)



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

Determinants of household food security in sugarcane growing regions

Poisson correlates of household food security

Table 9 presents results of the Poisson model of household food security regressed on various household and community-level factors known to influence household food security. Three different dependent variable measures of food security are used (separately) 0 HFIAS, HDDS and MAHFP. Before proceeding with regression analysis, multicollinearity among explanatory 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 – and others with VIF <14, such as total land size and household age were maintained in the model specification. Furthermore, choice of the Poisson model was selected by econometric validity of the results obtained with the Negative Binomial regression model method, which is used to test whether the dispersion of the dependent variable would be better fit by a Poisson or a Negative Binomial model.[5]

[5] 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.

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)
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
	(0.00725)	(0.00828)	(0.269)	(0.314)	(0.0958)	(0.108)
Interaction terms						
=1 HH grows cane * Head Sex		0.722		-0.222		-0.781

		(0.543)		(0.589)		(0.266)
=1 HH grows cane * Distance to town		-0.0733		0.0571+		-0.0553
		(0.474)		(0.0531)		(0.252)
=1 HH grows cane * Dist to market		0.0385		-0.00852		-0.0176
		(0.533)		(0.687)		(0.613)
=1 HH grows cane * =1 Buganda		-0.486		-0.812+		-1.100*
		(0.727)		(0.0695)		(0.0464)
=1 HH grows cane * =1 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

Results from the Poisson regression of HFIAS show that household participation in cane production is associated with a statistically significant 1.181 reduction in HFIAS ($p<0.1$), which is equivalent to a 17 percent reduction in food insecurity, relative to the sample mean of HFIAS (Table 9, Col.2). Other factors with a statistically significant and negative association with HFIAS (lower food insecurity) include male headed households, 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 these factors are associated with lower household food insecurity.

Factors that have a statistically significant positive association with food HFIAS (higher food insecurity) include spatial dummies for Busoga and Bunyoro subregions, as compared with Buganda, the base category ($p<0.05$). In addition, households with one or more members in wage employment, following an indigenous religion (as compared with being Catholic, the base category), household shocks pertaining to crop pets and diseases, and the distance to the nearest district town ($p<0.05$) all have a statistically significant and negative association with household food insecurity. If the binary household cane production variable is interacted with select variables, it does not change their association with HFIAS (Table 9, Col. 2).

A Poisson regression with HDDS as the household food security measure (Table 9-Col (3)) finds no statistically significant association of cane production on household diet diversity (i.e. food security). Yet, the value of annual income from salaried employment, household maximum adult female education, number of live small animals owned, and total household value of assets all have a statistically significant and positive association with HDDS (i.e. better food security). There is a statistically significant and negative association between residence in Bunyoro subregion, indigenous religion, natural shocks (drought, floods, mudslides) and the death of a household member. (Table 9-Col. (4) provides estimates with interaction terms, the results of which are similar to those in Col (3) though for cane growers, distance to the district is associated with better food security while being a cane grower in Buganda is associated with lower food security.

A Poisson regression of MAHFP (Table 9-Col (5)) shows that growing cane is associated with 1.06 additional months of adequate food provisions ($p<0.05$). This suggests that one benefit of growing cane enables households to better manage seasonality of food production, likely through higher household income. Other factors with a statistically significant association with MAHFP include male headship, maximum adult female education (years), the number of large animals and number of crops grown. Busoga and Bunyoro in comparison to Buganda are expected to have 1.65 and 1.06 lower MAHFP, while an additional household member (in AE terms, this would be a 20+ year old male) is associated with a 0.18 reduction in MAHFP ($p<0.05$).

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. The HFIAS

dependent variable is found to be 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. 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)[6].

Sugarcane growing households were likely to be classified as food secure and mildly food insecure levels and less likely to be classified as moderately and severely food insecure (Table 9). While the signs of marginal effects on the cane participation dummy are largely as expected, none have a statistically significant association with any of the HFIAS categories. Household asset value, growing more than one food crop, earning a non-farm salary, and a higher adult female education (years) all have a positive and statistically significant association with HFIAS categories. For example, an increase in household asset value is associated with a higher probability of being food secure or only mildly food insecure and is associated with a lower probability of being moderately or severely food insecure. It is not clear what the positive association of HFIAS with years of adult female education is capturing, but it could be an income source not included in the model. Higher levels of household asset value can improve food security though facilitating better credit access as well as potential sale of an asset if needed to make up for any shortfall in the household's expected farm and non-farm income during any given period.

Age of head is associated with better food security, which may be capturing the likely positive association of experience and wealth with food security. As in earlier analysis, households located in Busoga and Bunyoro are less likely to be food secure and mildly food insecure, relative to household from Buganda (base category) and more likely to be in the moderately and severely food insecure categories. An additional household member (adult equivalent) is associated with lower food security. This is consistent with similar studies and not surprising as an additional individual may offer additional income for the household, yet it is certain that an additional member will increase the household's food and other expenditures (Kirimi, *ud*).

[6] 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.

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)
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 (#)					
# live large animals	-0.134	0.0391	0.00569	-0.00780	-0.0403
	(0.116)	(0.0335)	(0.00517)	(0.00725)	(0.0350)
# live medium 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

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 percent 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.

Table 11. Impact of sugarcane production 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

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 13 and 14). Figure 14 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.

Figure 13. Results of distance matching

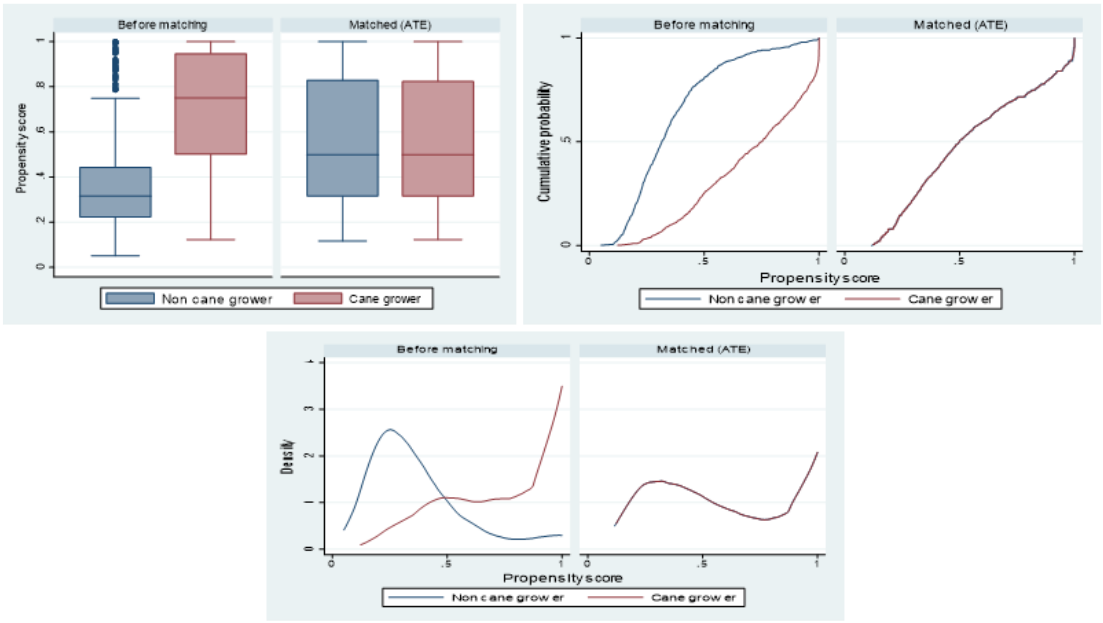
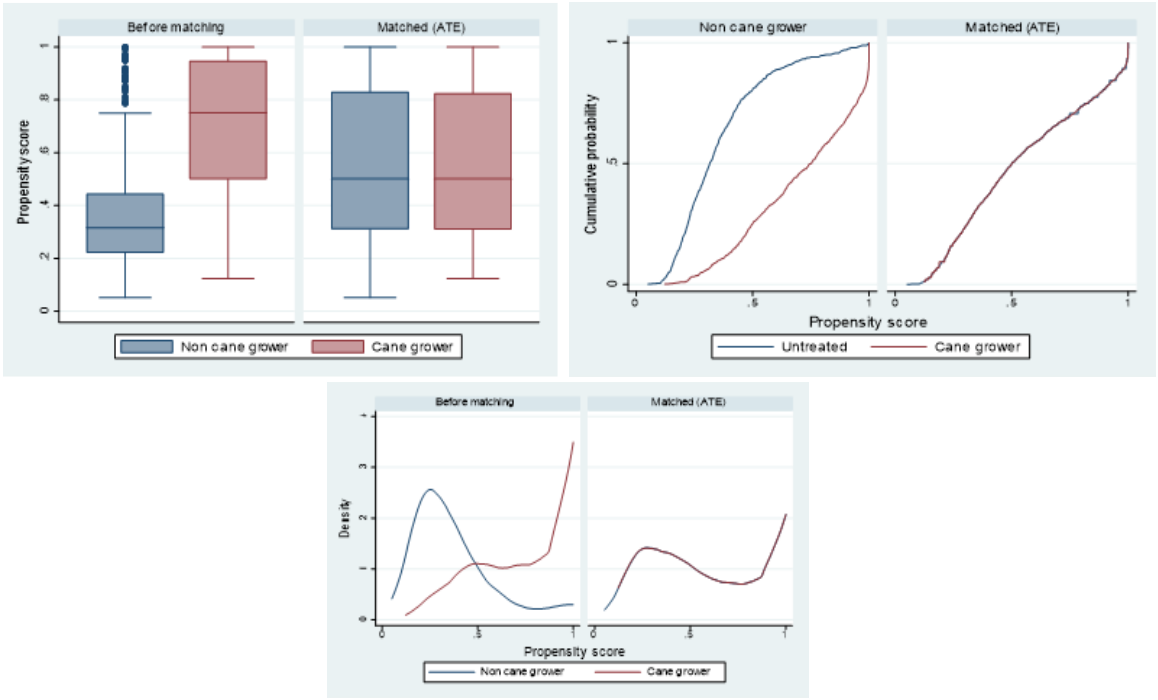


Figure 14. Results of one -to-one nearest neighbour matching

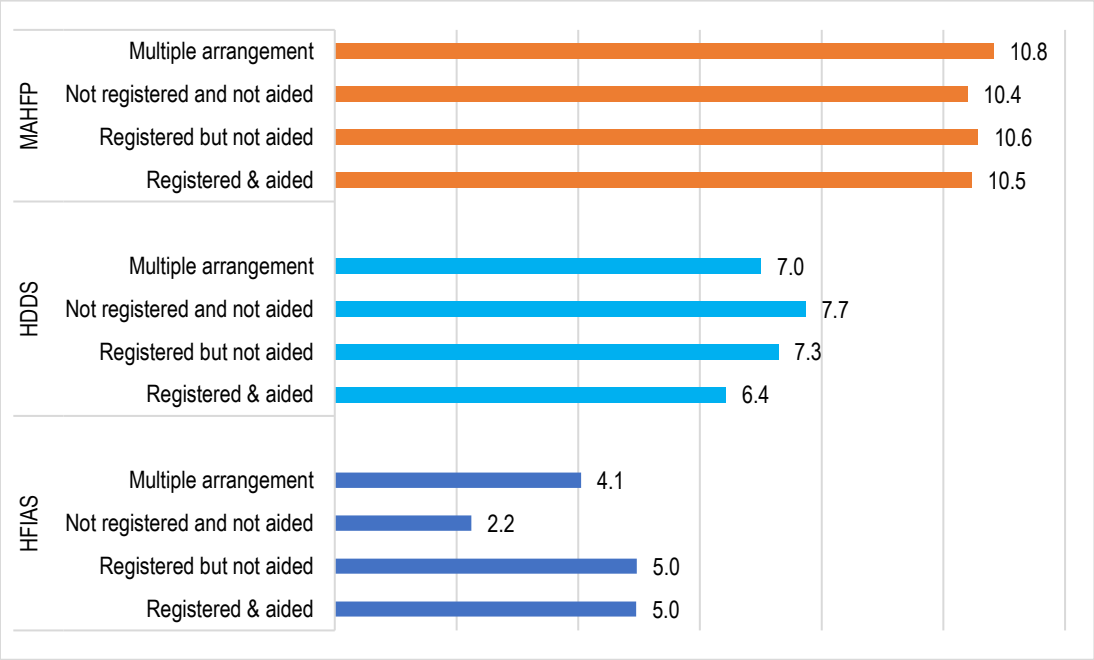


Does cane grower food security differ by grower-miller institutional arrangement?

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 type of grower-miller arrangement, followed by farmers with using multiple arrangements (any two of the 4 institutional arrangement categories in Figure 15). 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.

Figure 15. Mean values of food security measures by type of miller-grower institutional arrangement



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

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.

Does women's involvement in sugarcane production and marketing decisions influence household food security outcomes?

Households where male heads control decision-making with regard to all parcels had relatively better food security measures or a cane grower household. 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. The key insights here are that female heads/spouses are highly vulnerable to food security for both cane and non-cane growers. Also, partly, when women make decisions on parcels the productivity/income is lower due to gender gaps in access to resources/services etc beyond decision making. However, cane growers' decision making on plots by female heads had seemingly better food security outcomes to those by their fellow counterparts who do not grow cane.

We next estimate a Poisson model of HFIAS that includes all the explanatory variables in prior specifications, with the addition of a dummy variable that =1 for households where a female head/spouse has the final say on cropping choices. The statistically significant partial effect of this dummy indicates that HFIAS increased by 4.1 for households that have strong women's influence on crop choice ($p<0.1$) (Table 12, Col.2). This is equivalent to a 55 percent increase in this measure of food insecurity. 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 unexpected negative association between strong female head/spouse influence on crop choice and household food security may be because this dummy variable measure of women's influence has a high correlation (-0.75) with the dummy that =1 if household head is male (similar correlation but positive if a female head dummy is used). Because female headed households have lower levels of landholding and assets on average, they would be expected to have relatively lower food security outcomes compared with male headed households. It is possible that the high correlation between a male or female head dummy and the measure of women's influence implies that the negative sign on the women's influence dummy may be picking up part of the negative relationship between female headship and food security outcomes.

Table 12. Household food security and the gender and household position of a household's final decision-maker on crop choices

	Non-Cane growers			Cane grower			All		
Who makes the final decision on what to plant on plot at household	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*		
	41,84			*28,65*			*70,49*		
Population size	*3*			*6*			*8*		
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

If we instead use a decision dummy that =1 for households where a female head/spouse has the final say on allocation of crop sales income (Table 14, Col.2), the partial effect is again statistically significant though the magnitude is somewhat smaller at 2.9. This indicates that decision-making on crop sales income allocation held by a female head/spouse is associated with an increase in food insecurity. Again, this result may be confounded by very high correlation between the decision-making dummy and a dummy for the gender of head of household.

Table 13. Poisson model estimates of household food security and the gender and household position of household member making final decisions on crop choice

	HFIAS	HDDS	MAHFP

Indicator (s)	(1) Poisson coef.	(2) dy/dx	(3) Poisson coef.	(4) dy/dx	(5) Poisson coef.	(6) dy/dx
Decision on plot (Base=Male head)						
Female head/spouse	0.564***	4.099*	-0.0799	-0.514	-0.0517	-0.520
	(0.182)	(0.0104)	(0.0545)	(0.133)	(0.0499)	(0.294)
Jointly husband and wife	0.212**	1.276*	-0.0305	-0.201	0.0176	0.184
	(0.103)	(0.0478)	(0.0354)	(0.387)	(0.0271)	(0.515)
Other members & mixed decisions	0.0476	0.263	-0.00250	-0.0167	0.0140	0.146
	(0.131)	(0.719)	(0.0356)	(0.944)	(0.0305)	(0.647)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Institutional & location characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Agricultural characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.104***		1.300***		2.466***	
	(0.334)		(0.0939)		(0.0877)	
Observations	981	981	980	980	981	981

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

To attempt to alleviate this challenge, we create an alternative measure of women's influence on cropping. This is the share of household area cultivated from plots where a female head/spouse has the final decision on cropping choice. The results of using this share variable are similar to those above. Further exploration of this result is beyond the scope of this paper. As noted above, 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. We try another alternative and define the dummy for female head/spouse final decision-making to -1 if a female head/spouse has that authority on one or more household plots (not all of them, as with analysis above). While the results were slightly different, 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 food security outcomes.

Households with cropping choices are made jointly by the head/spouse (for all plots) have 1.27-point higher HFIAS (higher food insecurity), relative to the base (households where a male head makes the final decisions on crop choice). There are no statistically significant associations between the decision dummy and HDDS or MAHFP outcomes in Table 12 or Table 14.

Table 14. Household 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

Finally, we consider decision-making on allocation of crop sales income, which has a different result in that "Mixed decision making" -- where decisions on all plots owned by a household were not taken by either a male head/spouse, a female head/spouse, jointly by husband/wife, and by others – is associated with an HFIAS that is 2.1 points higher than those of households where male heads make this decision (Table 15).

Table 15. Poisson model estimates of household food security and the gender and household position of household member making final decisions on allocation of crop sales income

	HFIAS		HDDS		MAHFP	
	(1)	(2)	(3)	(4)	(5)	(6)

Variables	Poisson coef.	dy/dx	Poisson coef.	dy/dx	Poisson coef.	dy/dx
Allocation from plot (base=Male head)						
Female head/spouse	0.454**	2.964+	-0.0634	-0.414	0.0157	0.164
	(0.223)	(0.0836)	(0.0506)	(0.203)	(0.0498)	(0.753)
Jointly husband and wife	0.175	0.987	-0.0385	-0.254	-0.0252	-0.258
	(0.127)	(0.186)	(0.0366)	(0.289)	(0.0311)	(0.416)
Other members & mixed allocation	0.343***	2.111**	-0.0383	-0.253	-0.0150	-0.154
	(0.0954)	(0.000579)	(0.0337)	(0.254)	(0.0282)	(0.594)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Institutional & location chars.	Yes	Yes	Yes	Yes	Yes	Yes
Agricultural characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.259***		1.277***		2.409***	
	(0.367)		(0.0948)		(0.0991)	
Observations	981	981	980	980	981	981

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors computations using EPRC-PRCI Sugarcane survey dataset, 2021

V. Conclusions 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 of 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 and descriptive and econometric regression analysis of primary data collected from 1,171 households in these regions, including 983 cane growers and 788 non-growers.

Econometric analysis finds that sugarcane growing households were 17 percent less food insecure, on average, relative to non-cane growers, as measured by the 27-point Household Food Insecurity Access Scale (HFIAS) – while controlling for a variety of household and community-level factors known to influence household food security. Cane growing was also associated with one additional month of adequate household food provision (MAHFP), an improvement of 10 percent compared with non-cane growers. No significant association was found between cane production and HDDS, a 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 was 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. Other studies such as Mathenge et al (2010) found that a majority of female heads in Kenya were widows, who face great difficulties in terms of access to land and other assets and with increased care-giving responsibility within the family. Results of testing whether a household female head/spouse has strong influence in intra-household

decision making on crop choice or crop marketing show that is no evidence to support the expectation that a household with a female head or spouse with strong influence on crop choice or crop marketing. That said, this result may be due to high correlation between this women's influence measure and a separate gender or the household head dummy, which must remain in the model.

Policy recommendations

Policy reform and active public sector oversight of the sugarcane industry is within the mandates of the Ministry of Agriculture and the Ministry of Industry, Trade, and Commerce, and they must coordinate with each other and sector stakeholders to improve coordination between growers and millers. Following a difficult period of poor grower-miller coordination from 2018 to 2021 and a crash in 2021, regaining and maintaining the benefits of cane production for food security requires reforms to the industry's policy environment and public sector governance (Mbowa et al, 2023). Reforms are needed to promote improved coordination between growers and millers and consideration of related income stabilisation mechanisms for sugarcane farmers. In addition, extension services should promote sugarcane production on farms with 8 or more acres only, farmer adherence to maintaining food crop cultivation, and use of productivity-enhancing technologies in cane and food crop production.

There are several ways in which Ugandan policy makers can help to maintain the income and food security benefits of sugarcane growing in the country. First, Ministry of Trade, Industry and Cooperatives (MTIC) and the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) should provide a policy environment and public sector oversight of institutional arrangements between millers and growers that promote higher cane productivity and profitability for growers and more reliable market assurance for both growers and millers. Such arrangements would facilitate stronger coordination of local cane supply and demand, grower access to improved inputs, market assurance for both growers and millers, and a transparent and fair process for millers and grower association representatives to negotiate a cane purchase price each season, based upon a set formula (Mbowa et al, 2023). This level of coordination and oversight can only be achieved if MTIC and MAAIF take a more active role in governance and oversight of the cane industry and grower-miller relations (ibid, 2023).

Second, MAAIF extension services should promote sugarcane production on farms of no more than 8 acres, the adherence of cane growers to maintaining at least part of their cultivated area in food crops, and the adoption of productivity-enhancing crop technologies by cane producers for both cane and food crops. Productivity improvements in both cane and food crops in cane growing regions are vital to enable farm households to improve both their household incomes and food security.

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APPENDIX A.

Appendix Table A1. Classification of Household Dietary Diversity Score food group classification and common food items in each food group

	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

Source: Adapted by authors from classification and items outlined by Swindle and Bilinsky (2006).

Appendix Table A2: 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

Appendix Table A3. Household dietary diversity score by subregion and cane grower status, %

	Buganda				Busoga				Bunyoro			
HDDS food group	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

Appendix Figure A1. Predictive power of food security category covariates on the outcome