Farm Production Diversity, Household Dietary Diversity and Nutrition: Evidence from Uganda's National Panel Survey

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Abstract

Improved food security and nutrition remains a notable global challenge. Yet, food security and nutrition are areas of strategic importance with regards to the United Nations' Sustainable Development Goals. The increasingly weakening global food production systems pose a threat to sustainable improved food security and nutrition. Consequently, a significant population remains chronically hungry. As a remedy, farm production diversity (FPD) remains a viable pathway through which household nutrition can be improved. However, evidence is mixed, or unavailable on how FPD is associated with key nutrition indicators like household dietary diversity, energy, iron, zinc, and vitamin A (micronutrients) per adult. Thus, we use the Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) panel data from Uganda to analyze differential associations of sub-components of FPD on dietary diversity, energy, and micronutrients intake. Panel data models reveal that indeed crop species count, and animal species count (sub-components of FPD) are differently associated with household dietary diversity score (HDDS), available energy, and micronutrients. The animal species count was strongly associated with better HDDS, and energy, and micronutrients sourced from consumption of produce from own farm. However, the crop species count was more strongly positively associated with available energy, and micronutrients irrespective of the source. Therefore, inclusive, and pro-nutrition policies in the context of Uganda and similar ones, could more widely improve household nutrition through crop species diversification on farm because crops enable wider nutrition gains.

Key words: Uganda, panel data, food security, micronutrients intake, nutrition.

I. Introduction

Improved food and nutrition security remain a strong challenge in much of the developing world, despite this being a strategic aspect of central importance as regards the United Nations' Sustainable Development Goals. Nearly a billion people globally are chronically hungry, a matter that has been largely attributed to these people's inaccessibility to food (FAO, 2015; FAO, IFAD, UNICEF, WFP & WHO, 2019). However, access to food is largely determined by availability of food, as well as having sufficient financial resources to purchase food. Regrettably, access to financial resources is not guaranteed to most of the global population, hence cementing chronic poverty, hunger, and malnutrition (Reardon et al., 2000; Van Campenhout et al., 2016). Moreover, some of the common infrastructure from where households can access food – the markets – may be rendered ineffective in availing food to majority of the world's poorest, especially those in countries where the market infrastructure is even inadequately available (Islam et al., 2018; Sekabira & Nalunga, 2020). Therefore, farm production diversity remains a viable alternative to avail food to millions of the world's poorest, and avert menaces of severe food insecurity, hunger, and malnutrition (Minten and Barrett, 2008; Godfray et al., 2010; Jones et al., 2014; FAO, IFAD, UNICEF, WFP & WHO, 2019).

Unfortunately, there are knowledge gaps in understanding comprehensively the nexus of associations between farm production diversity (FPD) and key nutrition outcomes. Such improper understanding of this nexus hinders proper policy formulation thus scaling of appropriate innovations and investments against food insecurity and malnutrition, more so among vulnerable populations like smallholder farmers. Moreover, in most instances, evidence on how best smallholder households can access diverse diets is mixed. Some evidence points to market access being more important than diversifying farm production (Sibhatu et al., 2015; Sibhatu & Qaim, 2018a; 2018b; Olabisi et al., 2021). However, in the context of the least-developed countries like Uganda (Wikipedia, 2021; United Nations, 2021), where market infrastructure is poor and smallholder farm households trapped in poverty, such evidence may be inapplicable. Moreover, other evidence has documented FPD to be more important towards diversity in household diets and nutrition gains (Haddinott, 2012; Jones et al., 2014; Sibhatu et al., 2015; Koppmair et al. 2017; Islam et al. 2018; Sibhatu & Qaim, 2018a; Sibhatu & Qaim, 2018b; Whitney et al., 2018; Sekabira & Nalunga 2020; Muthini et al., 2020; Chegere & Stage, 2020; and Sekabira et al., 2021). Hence, empirical evidence linking FPD and nutrition outcomes is often mixed, disjointed, and incomprehensive (Shariff & Khor, 2005; Mello et al., 2010; Webb & Kennedy, 2014). For instance, none of the studies above explored the differential impacts of FPD sub-components (animal and crop species count) on daily energy, iron, zinc, and vitamin A intake, or other micronutrients available per adult among smallholder farm households. Closer efforts have been done by Muthini et al. (2020); however these covered only as far as dietary diversity without further considerations into the specific micronutrients. We contribute to this body of literature by asking the following questions:

1) Are sub-components (crop and animal species counts) of farm production diversity (FPD) differentially associated with household dietary diversity score, daily energy, iron, zinc, and vitamin A (micronutrients) available per adult?
2) Which of the two FPD sub-components is associated with better nutrition gains in the context of smallholder farm households?

To find appropriate answers to these questions we have used panel survey data from Uganda covering a representative sample of nearly 3,000 households consisting of the of 2009/10, 2010/2011, and 2011/2012 waves. The data is collected by the Uganda Bureau of Statistics annually and is freely available from the World Bank's Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) section. Because the data is a panel, we used panel data models specifying fixed effects and random effects to analyze the data. These panel data models enable variation in parameters of the model across studied households, which improves efficiency, hence in the quality of estimated results generated from combining households across the different data waves (Cameron & Trivedi, 2005; Wooldridge, 2010). However, because both the fixed effects and random effects estimators have assumptions that could easily be violated, we finally estimate the Mundlak which sufficiently connects the fixed and random effects estimations (Mundlak, 1978). The Mundlak concept is premised on assumptions of the FE and RE estimators. Answers to the above questions have enhanced our understanding of the linkages between FPD and nutrition. Such an interlinked understanding is indispensably important in designing appropriate food systems interventions (Shariff & Khor, 2005; Mello et al., 2010; Webb & Kennedy, 2014). Our results (that crop species count is strongly associated with better nutrition outcomes via the two main consumption pathways – own farm production, and markets) have also generated evidence to inform pro-nutrition and food security policies in Uganda, and those of a similar context, on how inclusiveness in nutrition gains especially among poor smallholder farmers can be achieved. More specifically, for instance, our results have among others inform the nutrition following policy initiatives: 1) The Uganda Nutrition Action Plan II (UNAP II) that spans between 2020 – 2025, and aims to leave behind none among Ugandans in scaling up nutrition outcomes. 2) The Uganda Food and Nutrition Policy (UFNP). 3) The Uganda National Agriculture Policy (UNAP). 4) Uganda's Multisectoral Food Security and Nutrition Project (UMFSNP) funded by the World Bank aiming mostly to eradicating malnutrition in children and rural dwellers.

The rest of the paper is organized as follows: next we present the conceptual framework in II, data in III, and elaborate methods in IV. We then present and discuss results in V, draw conclusions in VI, make acknowledgements in VII, references in VIII, and figures and tables in IX. Finally, we provide appendices in X that detail the tables displayed in IX.

II. Conceptual Framework

Generally, we hypothesized that FPD bears a positive influence on food security and thus nutrition outcomes, and we diagrammatically illustrate this in Figure 1. Conceptually, following Sekabira & Nalunga (2020), policies (agriculture, nutrition, or investment) influence the diversity of crops and animals species produced by farmers, thus influencing which crops or livestock species are prioritized for either direct consumption within households (own farm produce consumption pathway) or for sale to earn income and then buy food items from markets (market consumption pathway), that in the end dictate nutrition outcomes. Based on the conceptualization in Figure 1, and the empirical methodology highlighted above but elaborated later in this paper, we hypothesize that crop species count and animal species count, which are the key sub-components of FPD, associate differently with HDDS, energy, and micronutrients, that are available per adult per household.

III. Data

a. Data structure

Generally, the data used for this study is motivated by the 50x2030 Smart Agriculture Data Initiative of the International Fund for Agricultural Development (IFAD). More specifically, we use the Uganda National Panel Survey (UNPS) data collected by the Uganda Bureau of Statistics (UBOS), with technical support from the Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS – ISA) section of the World Bank. The sample size of the UNPS is about 3,200 households, that were previously selected and interviewed during the 2005/2006 Uganda National Household Survey (UNHS). Furthermore, the UNPS sample contains a randomly selected segment of split-off households that came into existence after the 2005/2006 UNHS. Moreover, the UNPS is both regionally and nationally representative. Each UNPS household is interviewed two times every year in an interval of six months to enhance respondent recall abilities. Data are collected and entered concurrently using computer-assisted interview applications (CAPI), installed on mobile personal computers that are operated by trained graduate enumerators. Subsequently, when data are fully cleaned and documented, they are made available to the public in a period of twelve months (World Bank 2021). The UNPS has seven waves including 2009/10, 2010/11, 2011/12, 2013/14, 2015/16, 2018/19, and 2019/20. We only use the latest 3 waves because these were possible to merge and analyze together given a common structure of households' identification. We had also separately worked with earlier waves on studying similar nutrition outcomes. Essentially, we built on analyses of Sekabira & Nalunga (2020) and Sekabira et al. (2021) who used 2009/10, 2010/2011, and 2011/2012 waves.

b. Measurement of key variables

Farm production diversity (FPD) was measured using the biodiversity index, which is a simple count of all crops and livestock produced on farm, as previously used by Di Falco & Chavas (2009), Jones et al. (2014), Sibhatu et al. (2015), Islam et al. (2018), and Sekabira & Nalunga (2020). Therefore, before generating the biodiversity index for FPD, we generated its sub-components, the species count based on crops, and the animal species count based on livestock. ***Dietary diversity*** was measured using the aggregated food index which measures the sum of food groups (12 in total) consumed in the household, including cereals, white roots and tubers, vegetables, fruits, meat and its products, eggs, fish, legumes nuts and seeds, dairy and its products, oils and fats, sweets and sugars, and spices condiments and beverages. The index has been elaborated by Swindale & Bilinsky (2006), and recently used by Sibhatu et al. (2015), Sekabira & Qaim (2017), Sekabira & Nalunga (2020) and Muthini et al. (2020). ***Energy, iron, zinc, and vitamin A (micronutrients)*** available per adult per household have been measured by computing quantities of food items consumed by households in kilograms and then computing edible proportions for each food item available. From the edible quantities, we computed quantities of energy in kilocalories and respective micronutrients, following Uganda food consumption tables documented by Hotz et al. (2012). For comparability of nutrition outcomes across households with different demographic compositions, we standardized household size into adult equivalents (AE) following (FAO,WHO & UNU, 2001)[1]. Edible quantities of energy and micronutrients were then divided by respective adult equivalents to produce comparable nutrition indicators available per adult across households. Following FAO,WHO & UNU, we also computed deficiencies for these micronutrients using as critical levels; 2400 kilocalories, 18 milligrams, 15 milligrams, and 625 retinal activity equivalent micrograms, for energy, iron, zinc, and vitamin A respectively.

c. *Data description*

From Table 1, the sample was on average aged 47 years, with a household size of 6 persons and formally educated up to primary level (8 years). The value of annual household assets averaged at 14 million UGX (4,000 USD). However, land size averaged at 0.7 acres. With regards to discrete variables, most of the sample (75%) had experienced shocks (weather issues like drought, famine, storms etc., health issues like death of the head, chronical illnesses etc.). Furthermore, most of the sample (67%) used mobile phones, and heavily relied on agriculture (47%) as their main income source. On the other hand, most households (75%) were rural, and their headship was dominated by males (66%). With regards to production diversity, on average, households farmed nearly 5 species of both crops and livestock of which majority (60%) were crop species. However, as seen in Figure 2, the average count of crop species farmed across the years, slightly declined between 2015 to 2019, while that for animals slightly increased over the same period. Furthermore, an average of 10 food groups (household dietary diversity (HDDS)) were consumed, with slight increases between 2015 and 2018 and staying stable between 2018 and 2019. Average consumption of energy and all considered micronutrients (2,556 kilocalories, 21 milligrams, 14 milligrams, and 672 rae-micrograms respectively) was slightly above FAO recommended thresholds per adult. Energy, iron, and zinc were mostly (74%, 67%, and 76% respectively) sourced from markets, whereas vitamin A was mostly (65%) sourced from own farm produce. From Figure 2, FPD was dominated by crop species perhaps because our sample is dominantly of smallholder farmers who mostly grow on crops, (Muthini et al. 2020).

[1] An adult male is taken as the standard with the highest nutritional requirements to survive, therefore using these thresholds, other persons nutritional requirements based on their sex (female or male) and age, are computed, and then standardized to their adult male equivalent

IV. Methods

We implemented the specification of the panel regression model in equation (1), to study the nature of association between the two FPD sub-components and various nutrition outcomes.

$$HNO_{it} = \alpha_0 + \beta_1 Animal\_SpeciesCount_{it} + \beta_2 Crop\_SpeciesCount_{it} + \theta \boldsymbol{X}_{it} + \gamma T_t + \varepsilon_{it} \qquad (1)$$

Where HNO_{it} is household nutrition outcome of interest (dietary diversity energy, zinc, iron, or vitamin A available per adult) of household i in year t. α_0 is the constant. β_1 and β_2 are respectively the effects of the animal, and crop species components of FPD that we aim to establish. θ is a vector of coefficients for observed household, and contextual characteristics, while γ is a time fixed effects parameter. ε_{it} is the normally distributed error term, and $\boldsymbol{X}_{it}$ is the vector of observed household (education, gender, and age of head, household size, assets, use of mobile phones, major source of income, and exposure to shocks), farm (land size), and contextual (location dummies by region, and urban versus rural) characteristics. These characteristics could alongside the considered FPD components, influence household nutrition outcomes. t is the year identifier variable capturing yearly fixed effects. We use equation (1) to empirically study the associations elaborated above for which we do not claim causality.

In equation (1), we control for the two sub-components in the same model and examine magnitudes of their coefficients to see which FPD sub-component is associated with better nutrition gains for households. We estimated equation (1) with random effects (RE) to control for heterogeneity within observed time variant and time invariant household characteristics, and fixed effects (FE) to control for unobserved heterogeneity (Wooldridge, 2010). Moreover, because the UNPS data is collected randomly, and are a panel, this also helped to reduce potential biases. But, because farmers self-select which crops and livestock species to farm based on own characteristics, and supposedly time-invariant covariates like gender of household heads become variant when headship changes for example due to death or divorce, this may yield systemic bias in results generated by the FE estimator (Wooldridge, 2010). Moreover, even the RE estimator's strong assumption that FPD cannot correlate with unobserved factors that may influence HDDS, energy, or micronutrients intake is also violated by self-selection (Wooldridge, 2010). Therefore, to control for potential violations of these assumptions, we use the Mundlak (MK) estimator, a pseudo-fixed effects estimator, that also controls biases caused by time-invariant unobserved heterogeneity, as would do a FE estimator, (Mundlak, 1978; Cameron & Trivedi, 2005). Essentially, the MK estimator helps us bridge the FE and RE estimations by controlling for means of variables, such that the FE assumption (there is a correlation between specific effects of studied individuals and the independent variables), and the RE assumption (there is no correlation between unobserved heterogeneity of studied individuals and the independent variables) are not violated – which if violated would yield biased estimates (Mundlak, 1978). Therefore, we interpret the MK estimator results. Nevertheless, in the first regression results involving HDDS, we present results from all estimators for comparisons – but present only MK estimator results with regards to energy and micronutrients, to avoid bulkiness

V. Results and discussions

From Table 2, model 1 and 2, we see that the combined (animal and livestock species count) FPD index is significantly associated with HDDS, but in different directions. Since we use different estimators that may treat data differently, we re-run these estimators each with the two main sub-components of the FPD index to further investigate if each of the two FPD sub-components will differentially be associated with HDDS. On separating the FPD index (crop and livestock) in models 3 and 4, the two sub-components are associated significantly with HDDS differently. Moreover, in both models the animal species count shows a positive and significant association, while the crop species count shows a negative and significant association. Furthermore, in models 5 and 6, we control for other covariates that may influence FPD, alongside the sub-components of FPD. Again, we observe a positive and significant association between the animal species count and HDDS. We re-run models 5 and 6 as an MK estimator presented in model 7, which we interpret.

From model 7, each additional species of animals kept within a household, is associated with a significant increase in HDDS of 0.04 food groups, which implies a 0.4 percentage point increase in HDDS. Surprisingly, such an association regarding crop species count is negative but not significant. Thus, the two sub-components of FPD are differently associated with HDDS. Nevertheless, since farmers largely grow staple groups of foods that are largely cereals or roots and tubers thus contributing mainly to household energy needs (Muthini et al., 2020), it may not be surprising that a crops species count may negatively or minimally be positively associated with HDDS, which is an indicator of dietary quality (diversity in diets), (Fongar et al., 2019). Muthini et al. (2020), also adds that producing animals enables households' access to a diversity of nutrition benefits in energy, proteins, fats, and micronutrients. Thus, this may explain the strong positive association of the animal species count with HDDS. However, since HDDS is an aggregated indicator of dietary quality (Sibhatu & Qaim, 2018a; Sibhatu & Qaim, 2018b; Fongar et al., 2019), we re-run model 7 with specific nutrition outcomes to establish the nature of association between FPD sub-components and certain micronutrients. We present these results later in Table 3.

However, Table 2, model 7 results do also highlight other factors that are significantly associated with HDDS. Our sample was barely educated with an average of 8 years of formal education, which is basically primary level. The sample was also dominantly rural (75%) which is characteristic of strong traditions that are heavily aligned towards consumption of staples and limited education (Kyomuhendo, 2003; Appiah-Opoku, 2007). Therefore, it may not be surprising that associated effects of education towards HDDS, were negative – contrary to our expectations. However, education in substantially more years (squaring normal education of dominantly rural samples), has been found to positively associate with nutrition outcomes, (Sekabira & Qaim, 2017a; Sekabira et al., 2021). On the other hand, experiencing shocks, was also surprisingly associated positively and significantly with HDDS. If a household experienced a shock (death of head, farm produce highly destructive drought, floods, or storm etc.), such a household was associated with a likelihood of 13% having better HDDS compared to one that never experienced shocks. Because our sample is dominantly rural, social networks are strong and functional for better livelihoods (Zuwarimwe & Kirsten, 2012; Klärner & Knabe, 2019), exposure to shocks attracts remittances and in-kind food contributions from family, friends, local, national and regional governments towards supporting affected households. Social networks support in form of remittances has also been previously found to enhance household welfare gains in Uganda, (Munyegera & Matsumoto, 2016; Sekabira & Qaim, 2017b). Moreover, Sekabira & Nalunga (2020) who analyzed earlier waves of the UNPS, did also find that experiencing shocks was associated with better HDDS. Assets also showed a significant negative association with HDDS. A one UGX million increase in the annual value of assets owned, was associated with a reduction of 0.1 scores in HDDS, implying a 0.8 percentage point decrease in the number of food groups consumed by households. Usually, most assets among smallholder households including productive assets (communication and transport equipment like mobile phones, motorcycles, or bicycles etc.) and non-productive ones are controlled by males who may work largely in non-farm activities (Barrett et al., 2001; Sekabira & Qaim, 2017a). However, considerable household financial resources, that would be used to purchase food or invest in food production – are diverted daily to service costs related to the use of these assets for instance, buying airtime and fuel, repairs etc. Hence, the variable costs burden presented to the household by availability of these assets may render assets to be negatively associated to HDDS. Moreover, even when such assets are liquidated by households, generated incomes are turned to strategic household investments like education and medication, but not food consumption (Sekabira & Qaim, 2017a). Nevertheless, some evidence has found assets to contribute importantly to household welfare, (Barrett et al., 2001).

From Table 3, the animal species count is consistently and significantly highly positively associated with energy and micronutrients sourced from own farm produce consumption. Specifically, each additional animal species kept on farm is associated with increases in daily intake per adult equivalent in energy, iron, zinc, and vitamin A, sourced from own farm produce consumption (0.95 kilocalories, 0.04 milligrams, 0.05 milligrams, and 0.17 rae-micrograms respectively translating to 0.1, 0.4, 1.0, and 0.04 percentage points increases). With regards to daily energy, iron, zinc, and vitamin A intake, small animals like poultry species, rabbits, or goats and sheep that formed most of the animal species count can easily be consumed for food within households anytime of the year without their availability being dependent on farming seasons. Moreover, larger animals like cattle and even small animals can regularly provide products like milk, and eggs that are good sources of micronutrients. Therefore, regular consumption of animals and their products, makes it possible for households to enhance their available energy and micronutrients. Our findings agree with Muthini et al. (2020), who found the animal species count to be more important to household dietary diversity than the crop species count. However, although the association is negative, the animal species count is not significantly associated with daily energy and micronutrients intake sourced from markets.

On the other hand, the crop species count is consistently and strongly significantly positively associated with daily energy and micronutrients intake regardless of the source, except for vitamin A sourced from markets, where the association is only positive but insignificant. In fact, with regards to energy, this association is stronger for energy sourced from markets, while the association is stronger for iron, zinc, and vitamin A sourced from own farm produce. Ideally, each crop species added to those farmed with in a household was associated with 5.9 and 18.8 kilocalories (0.6 and 0.9 percentage points) added to energy sourced from own farm produce consumption or markets respectively. With regards to iron, each additional crop species was associated with 0.4 and 0.1 milligrams (4.2 and 0.7 percentage points) added to daily iron intake sourced from own farm produce or markets consumption respectively. With regards to zinc, each additional crop species grown on the farm was associated with 0.3 and 0.1 milligrams (6.2 and 0.9 percentage points) added to daily zinc intake sourced from own farm produce, and markets consumption respectively. Lastly, each additional crop species grown on farm was associated with 1.1 and 0.6 rae_micrograms (0.3 and 0.2 percentage points) added to daily vitamin A intake sourced from own farm produce, and markets consumption respectively.

The strong positive association of the crop species count with energy and micronutrients sourced from own farm produce is not surprising since most smallholder farmers are engaged in subsistence agriculture. Hence one would expect that since they mostly consume what they grow, then a crop species count should bear a strong positive association with nutrition outcomes, as has been established previously (Jones et al., 2014; Sibhatu et al., 2015; Koppmair et al., 2017; Islam et al., 2018; Sibhatu & Qaim, 2018a; Sibhatu & Qaim, 2018b; Sekabira & Nalunga, 2020; Muthini et al., 2020; Sekabira et al., 2021). However, the crop species count positive and highly significant association with energy, iron, and zinc intake sourced from markets is somewhat surprising more so that smallholders are largely subsistence. Nevertheless, it may further confirm the importance of the markets consumption pathway which is only possible to farmers after gaining income from selling their produce, in this case crops as has been asserted in literature, (Sibhatu et al., 2015; Koppmair et al., 2017; Sibhatu & Qaim, 2018a; Sekabira & Nalunga, 2020; Sekabira et al., 2021). In good seasons, farmers sell their surplus crops or sell cash crops in all seasons to accumulate income that is used in purchasing foods from markets, hence the strong association of FPD towards energy and micronutrient intake sourced from markets. Moreover, some strategically valuable crops like vegetables are farmed within households but sold to earn money and smooth other consumption and non-consumption needs (Kabunga et al., 2014; Whitney et al., 2018). Yet, households usually never regularly consume such valuable crops like vegetables within households but spare them for sale, and usually consider it a luxury to consume these crops, (FANTA-2, 2010; Kabunga et al., 2014). The latter may explain why market derived vitamin A is lower, and that none of the FPD sub-components (animal or crop species count) was significantly associated with daily vitamin A intake, which is usually dominantly sourced from vegetables. Moreover, in a smallholder farmers' household setting, market sourced foods are mostly those essential foods that cannot easily be produced on farm, and these foods are mostly the energy dense ones consumed every day for instance, cereals or their products, oils and fats, beverages sugars and condiments. Therefore, it is not also surprising that the markets consumption pathway contributes the largest proportion of daily energy intake.

From Table 3, there are however other factors that are consistently and significantly associated with energy, and micronutrients intake, for instance gender effects, household size, and year variables, which we don't discuss here to prioritize our focus on FPD sub-components, which are our main covariates. We also prefer limiting bulkiness of the paper.

VI. Conclusion

Using nationally representative panel data from Uganda, we establish that indeed sub-components of FPD are differentially associated with HDDS, daily energy, and micronutrients available per adult. The animal species count is positively and highly significantly associated with HDDS, energy, and micronutrients sourced from consumption of own farm produce. On the other hand, the crop species count is strongly and positively associated with energy, and micronutrients intake irrespective of the source (own farm or markets) – clearly highlighting the strategic importance of crops towards better smallholder households' nutrition. Crops can easily be consumed directly or sold to markets for income to buy other food items. However, the association of the crop species count was stronger (magnitude of coefficients) with regards to energy, for the component sourced from consuming market foods, but stronger for iron, zinc, and vitamin A, for the component sourced from consuming own farm produce. In brief, with regards to individual micronutrients and energy intake, the crop species count shows a stronger association irrespective of the consumption pathway. Therefore, in a smallholder farmer context, diversification in crop species could be more important than animal species diversification towards availing more energy, and micronutrients per adult. Hence, comparative efforts (household or policy level) targeted towards crop species diversification in farm production could yield better nutrition outcomes. However, notice should be taken that our sample is traditionally more reliant on crops than animals to satisfy their food needs and general livelihoods. Hence, our results may not be binding in a context of countries that are predominantly dependent on animals (pastoralists), which is a limitation, and hence, must be interpreted cautiously in such contexts.

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IX. Figures and Tables

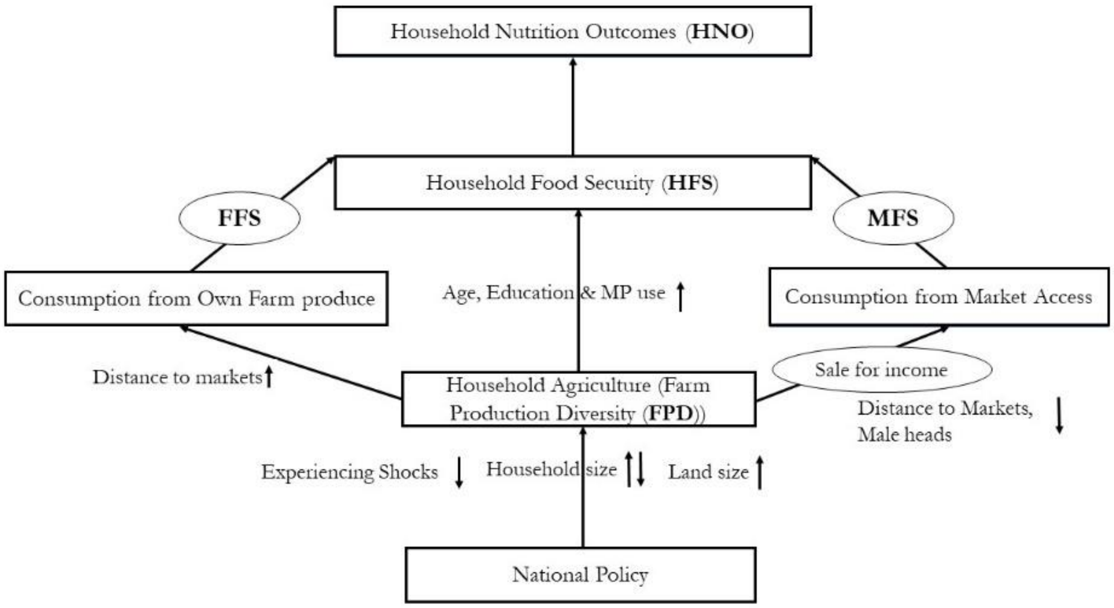

Figure 1: Conceptual frame for farm production diversity (FPD) and nutrition nexus (adapted: Sekabira & Nalunga, 2020)

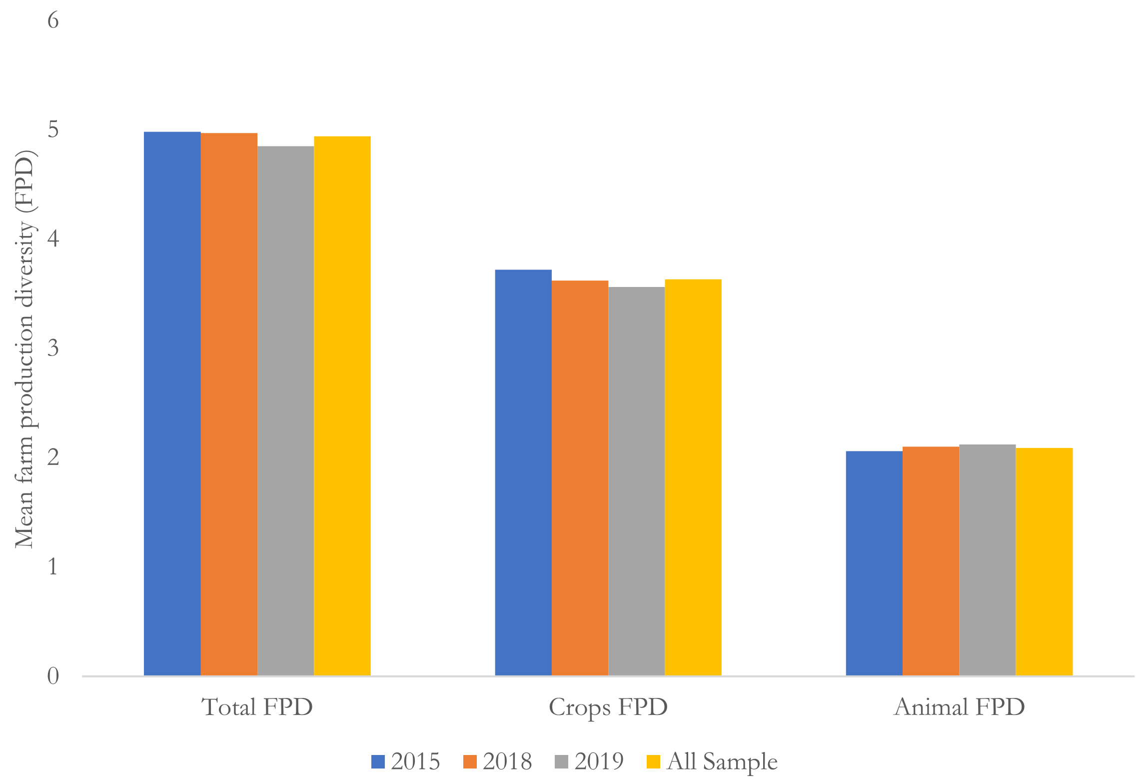

Figure 2: Farm production diversity (FPD) as generated from different sources (crops or livestock)

Table 1: Sample descriptive statistics (means or percentages) (N = 9,524)

Variables	2015	2018	2019	All sample
Age of head (years)	46.91 (15.92)	47.20 (15.80)	47.27 (15.68)	47.12 (15.80)
Household size (persons)	5.705 (3.208)	5.700 (3.121)	5.760 (3.090)	5.721 (3.142)
Education of head (years)	8.219 (4.961)	7.852 (4.772)	7.747 (4.635)	7.955 (4.803)
Total assets (million UGX)	14.40 (66.70)	13.20 (51.40)	15.00 (62.60)	14.20 (60.60)
Land size (Acres by GPS)	0.728 (3.635)	0.639 (1.796)	0.645 (1.530)	0.670 (2.504)
Experienced shocks (dummy)	0.714	0.751	0.784	0.749
Mobile phone use (dummy)	0.671	0.661	0.664	0.665
Farming is main income source	0. 455	0.471	0.489	0.471
Urban household (dummy)	0.257	0.242	0.243	0.247
Male head (dummy)	0.656	0.661	0.654	0.657
FPD (bio index)	4.979 (3.112)	4.969 (3.157)	4.852 (3.163)	4.935 (3.144)
Crops FPD (bio index)	3.718 (2.615)	3.620 (2.663)	3.557 (2.649)	3.633 (2.643)
Animals FPD (bio index)	2.062 (1.029)	2.102 (1.051)	2.115 (1.067)	2.092 (1.049)
HDDS (food groups)	9.986 (2.595)	10.24 (2.423)	10.23 (2.354)	10.15 (2.466)
Energy (kilocalories/AE)	3,370 (2,899)	2,174 (2,152)	2,066 (2,658)	2,556 (2,656)
Iron (milligrams/AE)	25.66 (23.72)	18.16 (13.76)	18.24 (18.08)	20.79 (19.35)
Zinc (milligrams/AE)	17.85 (16.99)	11.73 (9.540)	12.07 (10.79)	13.96 (13.25)
Vitamin A (rae_micrograms/AE)	811.4 (1,232)	528.7 (755.6)	674.3 (3,084)	672.4 (1,927)
From markets				
Energy (kilocalories/AE)	2,511 (2,552)	1,643 (2,075)	1,498 (2,242)	1,902 (2,348)
Iron (milligrams/AE)	16.87 (20.09)	12.27 (11.95)	12.29 (12.30)	13.89 (15.55)
Zinc (milligrams/AE)	13.44 (15.12)	8.916 (8.633)	9.171 (9.104)	10.59 (11.65)
Vitamin A (rae_micrograms/AE)	442.8 (1,023)	273.2 (542.6)	318.7 (755.3)	347.2 (807.1)
From own production				
Energy (kilocalories/AE)	1,211 (1,334)	820.1 (869.4)	776.8 (1,719)	940.6 (1,359)
Iron (milligrams/AE)	12.09 (13.51)	8.619 (8.885)	8.008 (15.65)	9.615 (13.06)
Zinc (milligrams/AE)	6.231 (7.335)	4.359 (4.878)	4.012 (6.696)	4.891 (6.461)
Vitamin A (rae_mg /AE)	497.0 (820.1)	353.3 (597.5)	462.9 (3,376)	437.6 (1,997)
Deficiencies				
Energy	0.430	0.625	0.670	0.571
Iron	0.448	0.571	0.597	0.536
Zinc	0.547	0.714	0.698	0.651
Vitamin A	0.598	0.739	0.710	0.681

FPD is farm production diversity, HDDS is household dietary diversity score, UGX is Uganda shillings (1USD = 3,557 UGX over considered years), in parentheses are standard deviations. Values without standard deviations are percentages, GPS is global positioning system, AE is adult equivalent, rae is retinal activity equivalents

Table 2: Association of farm production diversity (FPD) on dietary diversity score (HDDS)

Models Variables	RE (1) HDDS	FE (2) HDDS	RE (3) HDDS	FE (4) HDDS	RE (5) HDDS	FE (6) HDDS	MK (7) HDDS
FPD (bio index)	0.049*** (0.011)	-0.067*** (0.024)					
Animals FPD (bio index)			0.063*** (0.009)	0.067*** (0.015)	0.052*** (0.009)	0.071*** (0.015)	0.041*** (0.009)
Crops FPD (bio index)			-0.019* (0.011)	-0.141*** (0.021)	-0.014 (0.012)	-0.182*** (0.022)	-0.016 (0.012)
Urban household (dummy)					0.162** (0.069)	0.073 (0.140)	0.084 (0.126)
Eastern region					-0.173** (0.075)	-1.354 (2.168)	0.113 (0.392)
Northern region					-0.268*** (0.076)	2.952* (1.788)	0.101 (0.775)
Western region					-0.492*** (0.072)	-0.521 (1.292)	0.066 (1.158)
Male head (dummy)					0.0245 (0.054)	0.044 (0.210)	0.020 (0.188)
Mobile phone use (dummy)					0.148*** (0.057)	0.003 (0.090)	0.005 (0.081)
Age of head (years)					-0.003* (0.002)	-0.019* (0.010)	-0.011 (0.009)
Household size (adult equivalents)					0.003 (0.013)	0.012 (0.031)	-0.005 (0.027)
Education of head (years)					-0.052*** (0.012)	-0.039* (0.021)	-0.054*** (0.019)
Total assets (million UGX)					0.079*** (0.013[8])	-0.043 (0.027)	-0.110*** (0.020)
Experienced shocks (dummy)					0.286*** (0.059)	0.133 (0.083)	0.125* (0.074)
Land size (Acres by GPS)					0.004 (0.016)	-0.011 (0.023)	-0.019 (0.021)
Farming is main income source					-0.104* (0.056)	-0.017 (0.099)	-0.092 (0.087)
Year is 2018	0.107* (0.061)	-0.058 (0.067)	0.106* (0.061)	-0.053 (0.067)	0.171*** (0.059)	-0.071 (0.069)	0.125** (0.059)
Year is 2019	0.259*** (0.062)	-0.076 (0.069)	0.252*** (0.062)	-0.077 (0.069)	0.209*** (0.060)	-0.056 (0.069)	0.115* (0.060)
Means of variables							YES
Constant	7.357*** (0.044)	7.616*** (0.052)	7.528*** (0.046)	7.668*** (0.056)	6.878*** (0.158)	8.361*** (1.123)	5.929*** (0.436)
Observations	9,524	9,524	9,524	9,524	9,069	9,069	9,069
No. of households	3,511	3,511	3,511	3,511	3,446	3,446	3,446
Wald Chi2	37.52***		75.42***		283.84***		531.13***
F Value		2.95**		13.17***		5.58***	
Hausman test value		152.43***		170.54***		190.41***	

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; UGX is Uganda shillings (1USD = 3,557 USD); GPS is Global positioning system; RE is Random effects, FE is Fixed effects, MK is Mundlak

Table 3: Association of farm production diversity (FPD) on daily energy and micronutrients intake per adult equivalent (AE)

	Energy (kilocalories/AE)		Iron (milligrams/AE)		Zinc (milligrams/AE)		Vitamin A (rae_mg /AE)	
Models	MK (1)	MK (2)	MK (3)	MK (4)	MK (5)	MK (6)	MK (7)	MK (8)
Variables	Own farm	Market	Own farm	Market	Own farm	Market	Own farm	Market
Animals FPD	0.946***	-4.640	0.044***	-0.029	0.052***	-0.007	0.172***	-0.144
(bio index)	(0.191)	(3.538)	(0.011)	(0.030)	(0.010)	(0.022)	(0.040)	(0.286)
Crops FPD (bio	5.989***	18.79***	0.360***	0.105***	0.316***	0.101***	1.066***	0.578
index)	(0.247)	(4.583)	(0.015)	(0.039)	(0.013)	(0.029)	(0.052)	(0.369)
Urban hhd	-0.431	-1.756	-0.032	0.099	-0.089	-0.064	-0.736	3.708
(dummy)	(2.270)	(41.17)	(0.137)	(0.347)	(0.124)	(0.258)	(0.488)	(3.367)
Eastern region	1.380	27.09	0.397	0.200	0.131	-0.022	0.723	8.097
	(7.148)	(129.9)	(0.431)	(1.098)	(0.390)	(0.814)	(1.532)	(10.61)
Northern	-8.596	-154.7	0.119	-0.493	-0.375	-1.102	-1.383	16.43
region	(14.01)	(254.1)	(0.845)	(2.144)	(0.764)	(1.591)	(3.009)	(20.78)
Western region	-3.847	-143.8	0.633	-1.224	-0.117	-1.241	-1.197	-27.77
	(20.88)	(378.4)	(1.260)	(3.191)	(1.139)	(2.370)	(4.488)	(30.96)
Male head	8.635**	64.82	0.443**	0.563	0.348*	0.351	1.333*	4.502
(dummy)	(3.389)	(61.45)	(0.205)	(0.518)	(0.185)	(0.385)	(0.728)	(5.026)
Mobile phone	1.346	3.012	0.098	-0.027	0.094	0.062	0.212	-4.770**
use (dummy)	(1.457)	(26.42)	(0.088)	(0.223)	(0.079)	(0.165)	(0.313)	(2.161)
Age of head	-0.249	0.122	-0.012	-0.008	-0.009	-0.003	-0.067*	0.079
(years)	(0.168)	(3.047)	(0.010)	(0.026)	(0.009)	(0.019)	(0.036)	(0.249)
Household size	1.782***	-66.73***	0.088***	-0.309***	0.071***	-0.215***	0.390***	-0.652
(adults)	(0.488)	(8.873)	(0.029)	(0.075)	(0.027)	(0.056)	(0.105)	(0.725)
Education of	-0.472	-4.587	-0.029	-0.025	-0.026	-0.022	-0.071	0.287
head (years)	(0.338)	(6.138)	(0.020)	(0.052)	(0.018)	(0.039)	(0.073)	(0.502)
Total assets	0.049	-4.900	-0.008	-0.047	-0.006	-0.023	0.042	-0.650
(million UGX)	(0.380)	(6.900)	(0.023)	(0.059)	(0.021)	(0.044)	(0.081)	(0.570)
Experienced	1.807	14.78	0.144*	0.041	0.117	0.072	0.425	-0.922
shocks (dummy	(1.336)	(24.23)	(0.081)	(0.204)	(0.073)	(0.152)	(0.287)	(1.981)
Land size	0.138	-2.762	0.011	-0.022	0.010	-0.020	-0.109	-0.885
(Acres - GPS)	(0.371)	(6.723)	(0.022)	(0.057)	(0.020)	(0.042)	(0.079)	(0.550)
Farming is main	0.608	37.900	0.057	0.171	0.067	0.148	0.027	0.116
income source	(1.580)	(28.66)	(0.095)	(0.242)	(0.086)	(0.180)	(0.339)	(2.344)
Year is 2018	-7.227***	-306.3***	-0.353***	-1.278***	-0.367***	-1.376***	-0.895***	-13.36***
	(1.090)	(19.80)	(0.066)	(0.167)	(0.059)	(0.124)	(0.234)	(1.618)
Year is 2019	-11.08***	-419.6***	-0.636***	-1.368***	-0.609***	-1.368***	-1.246***	-11.50***
	(1.093)	(19.84)	(0.066)	(0.167)	(0.059)	(0.124)	(0.235)	(1.622)
Means	YES	YES	YES	YES	YES	YES	YES	YES
Constant	19.27**	2,310***	-1.329***	7.237***	-2.114***	4.054***	-0.417	78.94***
	(8.393)	(154.5)	(0.504)	(1.316)	(0.456)	(0.972)	(1.777)	(12.53)
Observations	9,069	9,069	9,069	9,069	9,069	9,069	9,069	9,069
No. of hhd	3,446	3,446	3,446	3,446	3,446	3,446	3,446	3,446
Wald Chi2	4904.14***	1508.57***	4708.43***	596.72***	4703.30***	728.01***	3737.22***	704.86***

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; UGX is Uganda shillings (1USD = 3,557 USD); GPS is Global positioning system; RE is Random effects, FE is Fixed effects, MK is Mundlak, hhd is household

X. Appendices

Appendix A: Association of farm production diversity (FPD) on dietary diversity score (HDDS)

Models Variables	RE (1) HDDS	FE (2) HDDS	RE (3) HDDS	FE (4) HDDS	RE (5) HDDS	FE (6) HDDS	MK (7) HDDS
FPD (bio index)	0.049*** (0.011)	-0.067*** (0.024)					
Animals FPD (bio index)			0.063*** (0.009)	0.067*** (0.015)	0.052*** (0.009)	0.071*** (0.015)	0.041*** (0.009)
Crops FPD (bio index)			-0.019* (0.011)	-0.141*** (0.021)	-0.014 (0.012)	-0.182*** (0.022)	-0.016 (0.012)
Urban household (dummy)					0.162** (0.069)	0.073 (0.140)	0.084 (0.126)
Eastern region					-0.173** (0.075)	-1.354 (2.168)	0.113 (0.392)
Northern region					-0.268*** (0.076)	2.952* (1.788)	0.101 (0.775)
Western region					-0.492*** (0.072)	-0.521 (1.292)	0.066 (1.158)
Male head (dummy)					0.0245 (0.054)	0.044 (0.210)	0.020 (0.188)
Mobile phone use (dummy)					0.148*** (0.057)	0.003 (0.090)	0.005 (0.081)
Age of head (years)					-0.003* (0.002)	-0.019* (0.010)	-0.011 (0.009)
Household size (persons)					0.003 (0.013)	0.012 (0.031)	-0.005 (0.027)
Education of head (years)					-0.052*** (0.012)	-0.039* (0.021)	-0.054*** (0.019)
Total assets (UGX)					7.9×10^{-8}*** (1.3×10^{-8})	-4.3×10^{-8} (2.7×10^{-8})	-1.1×10^{-7}*** (2.0×10^{-8})
Experienced shocks (dummy)					0.286*** (0.059)	0.133 (0.083)	0.125* (0.074)
Land size (Acres by GPS)					0.004 (0.016)	-0.011 (0.023)	-0.019 (0.021)
Farming is main income source					-0.104* (0.056)	-0.017 (0.099)	-0.092 (0.087)
Year is 2018	0.107* (0.061)	-0.058 (0.067)	0.106* (0.061)	-0.053 (0.067)	0.171*** (0.059)	-0.071 (0.069)	0.125** (0.059)
Year is 2019	0.259*** (0.062)	-0.076 (0.069)	0.252*** (0.062)	-0.077 (0.069)	0.209*** (0.060)	-0.056 (0.069)	0.115* (0.060)
Means of variables							YES
Urban household (dummy)							0.031 (0.151)
Region							-0.169 (0.387)
Male head (dummy)							-0.004 (0.196)
Mobile phone use (dummy)							0.239** (0.113)
Age of head (years)							0.008 (0.009)
Household size (persons)							-0.027 (0.031)
Education of head (years)							0.001 (0.025)
Total assets (UGX)							2.6×10^{-7}*** (2.2×10^{-8})
Experienced shocks (dummy)							1.065*** (0.147)
Land size (Acres by GPS)							0.042 (0.033)
Farming is main income source							-0.031 (0.115)
Constant	7.357*** (0.044)	7.616*** (0.052)	7.528*** (0.046)	7.668*** (0.056)	6.878*** (0.158)	8.361*** (1.123)	5.929*** (0.436)
Observations	9,524	9,524	9,524	9,524	9,069	9,069	9,069
No. of households	3,511	3,511	3,511	3,511	3,446	3,446	3,446
Wald Chi2	37.52***		75.42***		283.84***		531.13***
F Value		2.95**		13.17***		5.58***	
Hausman test value		152.43***		170.54***		190.41***	

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; UGX is Uganda shillings (1USD = 3,557 USD); GPS is Global positioning system; RE is Random effects, FE is Fixed effects, MK is Mundlak

Appendix B: Association of farm production diversity (FPD) on energy and micronutrients intake per adult equivalent (AE)

	Energy (kilocalories/AE)		Iron (milligrams/AE)		Zinc (milligrams/AE)		Vitamin A (rae_mg /AE)	
Models	MK (1)	MK (2)	MK (3)	MK (4)	MK (5)	MK (6)	MK (7)	MK (8)
Variables	Own farm	Market	Own farm	Market	Own farm	Market	Own farm	Market
Animals FPD	0.946***	-4.640	0.044***	-0.029	0.052***	-0.007	0.172***	-0.144
(bio index)	(0.191)	(3.538)	(0.011)	(0.030)	(0.010)	(0.022)	(0.040)	(0.286)
Crops FPD (bio	5.989***	18.79***	0.360***	0.105***	0.316***	0.101***	1.066***	0.578
index)	(0.247)	(4.583)	(0.015)	(0.039)	(0.013)	(0.029)	(0.052)	(0.369)
Urban hhd	-0.431	-1.756	-0.032	0.099	-0.089	-0.064	-0.736	3.708
(dummy)	(2.270)	(41.17)	(0.137)	(0.347)	(0.124)	(0.258)	(0.488)	(3.367)
Eastern region	1.380	27.09	0.397	0.200	0.131	-0.022	0.723	8.097
	(7.148)	(129.9)	(0.431)	(1.098)	(0.390)	(0.814)	(1.532)	(10.61)
Northern region	-8.596	-154.7	0.119	-0.493	-0.375	-1.102	-1.383	16.43
	(14.01)	(254.1)	(0.845)	(2.144)	(0.764)	(1.591)	(3.009)	(20.78)
Western region	-3.847	-143.8	0.633	-1.224	-0.117	-1.241	-1.197	-27.77
	(20.88)	(378.4)	(1.260)	(3.191)	(1.139)	(2.370)	(4.488)	(30.96)
Male head	8.635**	64.82	0.443**	0.563	0.348*	0.351	1.333*	4.502
(dummy)	(3.389)	(61.45)	(0.205)	(0.518)	(0.185)	(0.385)	(0.728)	(5.026)
Mobile phone	1.346	3.012	0.098	-0.027	0.094	0.062	0.212	-4.770**
use (dummy)	(1.457)	(26.42)	(0.088)	(0.223)	(0.079)	(0.165)	(0.313)	(2.161)
Age of head	-0.249	0.122	-0.012	-0.008	-0.009	-0.003	-0.067*	0.079
(years)	(0.168)	(3.047)	(0.010)	(0.026)	(0.009)	(0.019)	(0.036)	(0.249)
Household size	1.782***	-66.73***	0.088***	-0.309***	0.071***	-0.215***	0.390***	-0.652
(persons)	(0.488)	(8.873)	(0.029)	(0.075)	(0.027)	(0.056)	(0.105)	(0.725)
Education of	-0.472	-4.587	-0.029	-0.025	-0.026	-0.022	-0.071	0.287
head (years)	(0.338)	(6.138)	(0.020)	(0.052)	(0.018)	(0.039)	(0.073)	(0.502)
Total assets	$4.9x10^{-8}$	$-4.9x10^{-6}$	$-7.8x10^{-9}$	$-4.7x10^{-8}$	$-5.6x10^{-9}$	$-2.3x10^{-8}$	$4.2x10^{-8}$	$-6.5x10^{-7}$
(UGX)	$(3.8x10^{-7})$	$(6.9x10^{-6})$	$(2.3x10^{-8})$	$(5.9x10^{-8})$	$(2.1x10^{-8})$	$(4.4x10^{-8})$	$(8.1x10^{-8})$	$(5.7x10^{-7})$
Experienced	1.807	14.78	0.144*	0.041	0.117	0.072	0.425	-0.922
shocks(dummy)	(1.336)	(24.23)	(0.081)	(0.204)	(0.073)	(0.152)	(0.287)	(1.981)
Land size	0.138	-2.762	0.011	-0.022	0.010	-0.020	-0.109	-0.885
(Acres - GPS)	(0.371)	(6.723)	(0.022)	(0.057)	(0.020)	(0.042)	(0.079)	(0.550)
Farming is main	0.608	37.900	0.057	0.171	0.067	0.148	0.027	0.116
income source	(1.580)	(28.66)	(0.095)	(0.242)	(0.086)	(0.180)	(0.339)	(2.344)
Year is 2018	-7.227***	-306.3***	-0.353***	-1.278***	-0.367***	-1.376***	-0.895***	-13.36***
	(1.090)	(19.80)	(0.066)	(0.167)	(0.059)	(0.124)	(0.234)	(1.618)
Year is 2019	-11.08***	-419.6***	-0.636***	-1.368***	-0.609***	-1.368***	-1.246***	-11.50***
	(1.093)	(19.84)	(0.066)	(0.167)	(0.059)	(0.124)	(0.235)	(1.622)
Means of variables								
Urban hhd	-37.08***	324.5***	-2.108***	2.411***	-1.837***	1.816***	-5.618***	20.70***
(dummy)	(2.988)	(55.38)	(0.179)	(0.474)	(0.162)	(0.349)	(0.628)	(4.472)
Region	3.641	-15.62	-0.031	0.268	0.172	0.367	0.693	6.446
	(6.981)	(126.6)	(0.421)	(1.068)	(0.381)	(0.793)	(1.500)	(10.35)
Male head	-12.56***	-144.9**	-0.722***	-1.388**	-0.578***	-0.831**	-1.961**	-9.627*
(dummy)	(3.645)	(66.60)	(0.219)	(0.565)	(0.198)	(0.418)	(0.778)	(5.423)
Mobile phone	5.040**	106.5**	0.243*	0.184	0.229*	0.399	1.061**	3.716
use (dummy)	(2.372)	(44.44)	(0.141)	(0.383)	(0.128)	(0.281)	(0.493)	(3.566)
Age of head	0.313*	-3.386	0.018*	-0.014	0.015	-0.015	0.102***	-0.345
(years)	(0.173)	(3.147)	(0.010)	(0.027)	(0.009)	(0.019)	(0.0371)	(0.257)
Household size	-1.998***	-10.79	-0.127***	-0.211**	-0.094***	-0.171**	-0.346***	-3.637***
(persons)	(0.606)	(11.21)	(0.036)	(0.096)	(0.033)	(0.071)	(0.127)	(0.906)
Education of	-1.834***	-4.601	-0.105***	-0.235***	-0.089***	-0.151**	-0.220**	-2.470***
head (years)	(0.508)	(9.478)	(0.030)	(0.081)	(0.027)	(0.059)	(0.106)	(0.762)
Total assets	$2.5x10^{-6}$***	$6.5x10^{-5}$***	$1.4x10^{-7}$***	$5.5x10^{-7***}$	$1.3x10^{-7}$***	$4.4x10^{-7***}$	$3.2x10^{-7}$***	$3.9x10^{-6***}$
(UGX)	$(4.5x10^{-7})$	$(8.3x10^{-6})$	$(2.7x10^{-8})$	$(7.1x10^{-8})$	$(2.4x10^{-8})$	$(5.3x10^{-8})$	$(9.4x10^{-8})$	$(6.7x10^{-7})$
Experienced	13.57***	44.77	0.673***	0.517	0.626***	0.285	2.018***	0.519
shocks(dummy)	(3.107)	(58.25)	(0.185)	(0.502)	(0.168)	(0.368)	(0.645)	(4.672)
Land size	4.485***	-18.33	0.262***	-0.155	0.227***	-0.094	1.247***	-2.156**
(Acres, GPS)	(0.721)	(13.61)	(0.043)	(0.118)	(0.039)	(0.086)	(0.149)	(1.087)
Farming is main	25.58***	-279.0***	1.484***	-1.672***	1.369***	-1.205***	4.262***	-14.89***
income source	(2.373)	(44.33)	(0.142)	(0.381)	(0.128)	(0.280)	(0.495)	(3.563)
Constant	19.27**	2,310***	-1.329***	7.237***	-2.114***	4.054***	-0.417	78.94***
	(8.393)	(154.5)	(0.504)	(1.316)	(0.456)	(0.972)	(1.777)	(12.53)
Observations	9,069	9,069	9,069	9,069	9,069	9,069	9,069	9,069
No. of hhd	3,446	3,446	3,446	3,446	3,446	3,446	3,446	3,446
Wald Chi2	4904.14***	1508.57***	4708.43***	596.72***	4703.30***	728.01***	3737.22***	704.86***

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; UGX is Uganda shillings (1USD = 3,557 USD); GPS is Global positioning system; RE is Random effects, FE is Fixed effects, MK is Mundlak, hhd is household