Smallholder output market participation, market food environment and household food purchase diversity in rural Uganda

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Abstract:
Although rural populations in SSA are acquiring an increasing part of their food from markets, the role that the market food environment plays in the linkage between agriculture and nutrition is understudied. Understanding how the rural market food environment can be made to work to deliver nutrient-rich food is important to tackling undernourishment in SSA. Without accounting for market diversity, recent studies have shown the significance of market access to household and individual diet diversity, but the evidence is still inconclusive. We use three waves of panel data from rural Uganda to describe the diversity in market food availability and to test the hypothesis that small-farm household output market participation influences the rural market food environment and positively impacts their food purchase diversity. We find a positive statistically significant effect of output market participation on the food purchase diversity score. In addition, village food sales diversity score has a positive impact on non-staple food purchase diversity. Our results highlight the need to not only enhance market accessibility but also to increase market availability of non-staples and biofortified foods in order to increase non-staple food purchase diversity. In this respect, policy efforts to influence smallholder market participation and hence market availability of nutritious food could be directed to increasing their access to improved seed, fertilizer, and extension contact.

Key words: Smallholder output market participation; rural-market food environment; food purchase diversity; Uganda.

1. Introduction

Majority of people who consume a nutrient-deficient diet live in Southern Asia and Sub-Saharan Africa (SSA) (FAO, IFAD, UNICEF, WHO, 2022). Millions of these people in SSA still live in rural households and depend on small farms (less than 3 acres (IFAD, 2016)) for a livelihood, predominantly growing food crops. Although they supply the larger proportion of food consumed in their countries (Herrero et al., 2017; Rapsomanikis, 2015; Wiggins & Keats, 2013), smallholder households are the most undernourished population of SSA (Headey et al., 2018; Sibhatu and Qaim, 2017; Riesgo et al., 2016). Slow progress towards achieving Sustainable Development Goal 2– to end all forms of malnutrition, has been reported for SSA (FAO, IFAD, UNICEF and WHO, 2022; Babu et al., 2022). For instance, in the East African region, 26%-30% of children under five are still stunted (Statista, 2022). Bhutta et al. (2013) indicate that undernutrition costs SSA up to 11% of their national income.

A sustainable strategy to combat malnutrition in low-resource populations is a healthy diet with diversity and adequate food quantities (Thompson and Amoroso 2014). Although smallholder

households mainly consume own-produced food, market access is important for households to acquire non-staple foods and has been found to be a driver of improvements in diets and nutrition among rural populations in LMICs. Markets provide more food choices to support diet diversity than production diversity (Nandi et al., 2021; Sibhatu and Qaim, 2017; Koppmair et al., 2017). Smallholders also depend on markets to guard themselves against seasonality (Sibhatu and Qaim, 2017; Muthini et al., 2020; Jones 2017; GLOPAN, 2016; Frelat et al., 2016; Luckett et al., 2015). This evidence, therefore, suggests that rural market food environments have a role to play in shaping smallholder household dietary choices and must be comprehended if it is to be positioned to alleviate diet diversity gaps of smallholders.

The food transition (Wall et al., 2018) taking place in LMICs where traditional diets are being replaced by highly processed high-fat and high-energy fast foods (associated with a rise in overnutrition and non-communicable diseases (Popkin, 2015)), has seen a rise in supermarkets, fast food restaurants and street food venders in urban areas. However, in rural SSA, traditional (wet) markets selling grains, pulses and fresh foods are still the norm. These markets typically have seasonal shortages and a limited variety of food since they rely on rain-fed farming. Food markets in rural areas are also characterized by low accessibility and low affordability because of remoteness and low incomes of the majority of the households (Downs et al., 2020; HLPE, 2017). Strategies that circumvent these limitations would create healthy food environments for smallholder households and contribute to alleviating malnutrition.

FAO (2016) express food environments as "the foods available to people in their surroundings as they go about their everyday lives, and the nutritional quality, safety, price, convenience, labelling and promotion of these foods". Downs et al. (2020) differentiate between natural and built food environments with natural environments accounting for gathered and cultivated foods for subsistence whereas built environments comprise of various foods marketing channels including formal and informal outlets. Turner et al. (2018) categorizes the food environment based on external factors and personal/individual-level factors that influence food choices in the market. While various authors (FAO, 2016; Downs et al., 2020; HLPE, 2017; Turner et al., 2017; Herforth and Ahmed, 2015) identify at least five dimensions of food environments including availability, accessibility, affordability, convenience, and desirability, Turner et al. (2018) highlight that a food must be available before it can be accessible.

In the rural market context of SSA, food availability can be measured by the presence of food sellers in both formal and informal outlets, their density as well as location in the community. On the other hand, accessibility refers to proximity to the food sellers or market spaces and the means to get there. This implies that long distances increase transportation costs and reduce market accessibility. According to Toure et al. (2021) food availability interacts with the individual features like accessibility to affect dietary behavior. Similarly, affordability yet another individual characteristic that relates prices of food items to incomes of buyers, acts together with food availability to affect diet choices. In Herforth and Ahmed (2015), convenience is shown to be intertwined with accessibility and can be reflected by type and number of food outlets in a community. However, methodological challenges that are encountered in measuring food environments in LMICs (Toure et al.; Ahmed et al., 2021; Downs et al., 2020) would make it difficult to study the relationship between food environment factors and dietary behaviour.

The food environment in rural areas constitutes food from own-production and food supplied in markets. Farm production diversification has a positive impact on household diet diversity to some extent and may depend on the context (Chegere and Stage, 2020; Koppmair et al., 2017; Sibhatu, et al., 2015). However, market access increases a farm household's food choices and has been argued to have a stronger influence on diet diversity (Nandi et al., 2021; sibhatu and Qaim, 2017). A related strand of studies also demonstrates a positive agricultural income effect on household diets and nutrient intake (e.g., Chegere and Kauky, 2022; Kilimani et al. 2022; Carletto et al., 2017; von Braun, 1995). Studies on agricultural income effect and market accessibility (using proxy measures like travel time and distance to an agrifood market or an all-weather road) essentially assume availability of diverse foods in markets. This likely explains why some studies find no association between diet diversity and market access (Usman and Callo-concha, 2021). Toure et al. argue that accessibility or market access does not independently measure the food environment, and needs to be interacted with food availability in order to understand how the food environment affects dietary choices. Similarly, individual affordability resulting from increase in agricultural incomes needs to be interacted with the external dimension of food availability when evaluating the market food environment and its effect on diet diversity. If markets are lacking diversity, even wealthy households might not be able to guarantee a diverse diet. Conversely, studies that validate smallholders as the source of market food availability and lower food prices (World Bank, 2007; Jensen and Miller, 2011) usually have a focus on food security foods comprising staples (e.g., grains and pulses in SSA), and pay little or no attention to the diversity of foods in markets.

Few studies have analysed rural market accessibility characteristics together with food availability and their relationship with dietary choices and nutrition in SSA. Notable among them is Headey et al. (2019) who showed that market availability measured by a market diversity score of non-staple food groups improved child dietary diversity in rural Ethiopia. Using data from Ethiopia, Sibhatu and Qaim (2017) examined the number of food groups purchased with farm and non-farm income. Similarly, Matita et al. (2021) examined food purchase diversity among rural Malawian households and its effect on household dietary diversity while Muthini, et al. (2020) provided a separate analysis of diet diversity obtained from own-production and from dependence on markets among farm households in Kenya. While nearly all small-farm households in SSA produce carbohydrate-rich staples, those that bring to the market non-staple foods like vegetables, fruits, and animal source foods increase availability of these foods in the community and support a healthy food environment. We expect that smallholders who don't produce these foods but sale their surplus output in market spaces increase their accessibility to non-staples. Further, the income earned by market participants may increase their purchasing power to buy the foods available in their environment subject to food prices. To this end, Bellon et al. (2016) showed that market diversity, measured by household reported food purchase diversity, has a positive relationship with mother's dietary diversity in southern Benin. However, such a measure of market diversity might be an indicator of household/individual wealth status rather than availability of diverse foods in the market.

The importance of small-farm output market participation on diet diversity in SSA remains inconclusive. While Chegere and Stage (2020) found no association between the share of marketed output and household diet diversity, other studies like Sibhatu et al. (2018) and Koppmair et al.

(2017) revealed that small farm incomes were beneficial to diet diversity. Disparities in the food environment of rural markets could be the cause of this disagreement in the literature. We utilize smallholder output market participation as an indicator of the rural market food environment dimensions of availability, accessibility and affordability. These dimensions were shown in Pitt et al., (2017) to be significant influencers of food purchase behaviour. Specifically, to analyse the external dimension of food availability, our approach consists of constructing a village food sales diversity score using data on smallholder food group sales as opposed to using food purchases employed in Bellon et al. Our contribution to the literature further lies in using panel data to investigate whether smallholder household food crop market participation and village food sales diversity score impact household non-staple food purchase diversity. Apart from Sibhatu and Qaim (2017) who used descriptive analysis to show the number of food groups consumed by farm-households from purchases, the effect of smallholder output market participation and market diversity on household food purchase diversity is understudied.

The specific objectives of this study are

i) To examine market availability of diverse food groups and its impact on household food purchase diversity,
ii) To analyse the impact of smallholder output market participation on household food purchase diversity.

The study is guided by the following research questions.

i) What food groups do smallholders bring to market spaces during different seasons of crop production and what food groups do market participants purchase from markets vs non-participants?
ii) Does output market participation in the village enable semi-subsistence farmers to purchase non-staple food groups?

2. Country context and conceptual framework

Uganda is a landlocked country with a poverty rate of about 30% based on the national poverty line (UBoS, 2022). About 56% of Ugandans are moderately food insecure while up to 15% fall in the severely food insecure category. The characteristic Ugandan diet is devoid of diversity. Agriculture still employs over 60 percent of the population and about 50% are subsistence farmers. The government of Uganda (GoU) in the 2040 Vision (NPA, 2015) envisions a transformation of agriculture from subsistence to market oriented farming in a bid to improve livelihoods, eradicate poverty and achieve sustained economic growth. Based on the premise of the important role that food products have in smallholder household income, the GoU interventions such as the Operation Wealth Creation (OWC) (MAAIF, 2020) have prioritized increasing productivity and marketing of food agricultural products. The prioritized food groups for the OWC include both staples (e.g., maize and beans) and non-staples (citrus fruits, vitamin-A rich fruits, avocados, dairy, meat, fish and poultry). Support to farmers from the OWC initiative has included providing planting materials, dairy heifers, live birds, animal feeds, fish fingerlings and value addition equipment. These interventions have had a bearing on availability of non-staples in rural market spaces and have therefore improved the food environment of smallholders.

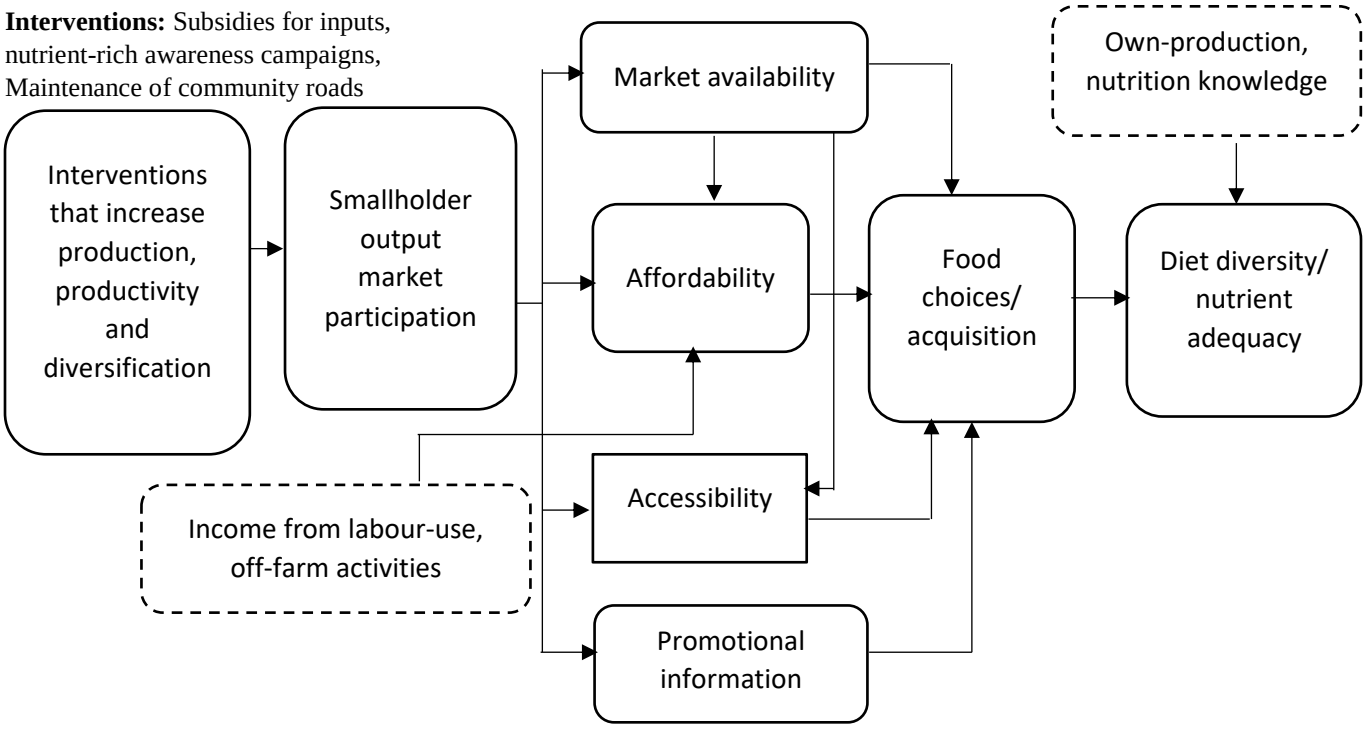

Figure 1: Conceptualized relationship between smallholder output market participation, market food environment and food purchase diversity

Source: Adapted from Turner et al., 2019; Downs et al.,2020

Our study defines output market participation as a smallholder household's sale of surplus food production. We conceptualise smallholder output market participation as an indicator of the rural market food environment. In Figure 1, output market participation is expected to contribute to the external dimension of market food availability and to influence personal dimensions of household market accessibility and affordability, subject to food prices. Smallholders may also participate in promotional activities, for instance, when they supply to the market biofortified food crops, they create awareness especially in areas where these crops have not been widely adopted. Agricultural interventions such as training in good agricultural practices and support in improved technology adoption that raise a smallholder's competitive production as well as interventions that reduce a farmer's transaction costs e.g., accessible/all-weather roads or ownership of transportation equipment, are important influencers for the market participation of semi-subsistence farmers (Ruijs et al., 2004; Jari and Fraser, 2009; Barret, 2008). Thus, agricultural interventions that increase a smallholder's food market participation can potentially affect the rural market food environment, and consequently affect food purchase diversity. However, the above linkages are mediated by factors such as household nutritional knowledge. Based on the above conceptual framework, we test the following hypotheses: (i) that smallholder output market participation

impacts food purchase diversity because it increases market accessibility and purchasing power of the smallholders, and (ii) village sales diversity, a result of food groups made available by smallholders, positively impacts food purchase diversity.

3. Data source and description of variables

Data

We use a household panel dataset, which was collected by Feed the Future innovation lab for nutrition in 2012, 2014 and 2016. The data were collected as part of the Community Connector Project implemented in a partnership by the GoU and USAID. The project implemented interventions that would improve livelihoods, health and nutrition of rural households in 15 districts located in northern and southwestern Uganda. However, surveys were conducted in only 6 representative districts. Interventions targeted women and children to increase women's participation in household decision making and their health seeking behavior, improve IYCF practices, improve household food security, improve household adoption of agricultural technologies, increase farm productivity and production diversity, increase household use of financial services and increase household agricultural asset ownership – to mention a few. Information such as household demographics, crop production and marketing, livestock products and marketing as well as source of food consumed in a 24-hour and 7-day recall periods were collected in the surveys. Questionnaires were administered to 3,597 households in the baseline survey and to 3,302 and 3,196 households in the follow-up surveys in 2014 and 2016. The key respondent in these surveys was a caregiver or woman of reproductive age in the range of 18-46 years. Details concerning the design of the survey are provided in Bashaasha et al. (2020).

Dependent variables

Our dependent variables measure changes in consumption of a diverse and nutritious diet. We make use of a household food purchase diversity score (FPDS) and a household non-staple food purchase diversity score (NFPDS). We construct the FPDS following a food group based indicator that considers nine nutritionally significant food groups, correlated with achieving nutrient adequacy of an individual (FAO and FHI 360, 2016). Thus we allocate food items purchased by the households to the following nine food groups: *Cereals/grains and starchy staples; Legumes and nuts; Dark green leafy vegetables; Vitamin-A rich vegetables & fruits; Other vegetables; Other fruits; Dairy & dairy products; Meat, Fish, Poultry; and Eggs.* Accordingly, the FPDS ranges from 0 to 9. Food items contained in each group are shown in Table 1. A higher FPDS is expected to translate into a more diverse diet required for nutrient adequacy. By leaving out the *Cereals/grains and starchy staples* and *Legumes and nuts* food groups that are typically consumed by smallholders from own-production in Uganda, we further construct a non-staple food purchase diversity score (NFPDS) with seven food groups. The NFPDS is a continuous variable which ranges from 0-7.

Table 1: Food group classification for market diversity score and food purchase diversity score

	Food group	**Food items**

1	Cereals, Plantain, Roots and Tubers	Quality Protein Maize; Maize- other varieties; Sorghum; Millet; Rice; Amaranth grain; Other cereal; Banana matooke; Sweet bananas; Roasting bananas; Cassava; Irish potato; Sweet potato (White); Yams; Other root, tuber & plantain
2	Legumes and Nuts	Iron-rich beans; Other beans; Soy bean; Cowpeas; Ground nuts; Other legumes
3	Dark green leafy vegetables	Amaranth leaves; other dark green leafy vegetables
4	Vitamin-A rich Vegetables &Fruit	Sweet potatoes (orange); Mangoes/ Pawpaw; Pumpkin/ Carrot
5	Other Vegetables	Cabbage & other light green leafy vegetable; Tomato; Okra; Other vegetable
6	Other Fruits	Citrus/oranges; Passion fruit; Jackfruit; Pineapple; Avocado; Other fruit
7	Dairy products	Milk; Ghee; Butter; Yoghurt/sour milk
8	Meat, Fish, Poultry	Beef; goat; mutton; organ meat; pork; Live birds; Fish
9	Eggs	Eggs

Key independent variables

The main independent variable is a farmer household's crop output market participation in a period of 12 months. Uganda has two rain seasons which fall within the two calendar periods for which crop production data was collected, i.e., Season 1 (January-June) and Season 2 (July-December). We use three output market participation indicators: First we express market participation as a binary variable equal to 1 if a smallholder household sold a positive share of at least one food crop they produced in a season and zero otherwise. Second, following Koppmair et al. (2017) we construct the share of marketed food crop output out of total food output. The third market participation indicator is a count of the number of food crops sold in each season by a household. The second key independent variable is the village sales diversity score (VSDS). It measures food group availability in the community market spaces. We constructed VSDS as a median number of the food groups sold at a household stall or in a nearby/village market by smallholders clustered at parish/village level. The categorisation of food items sold into food groups is shown in Table 1.

Control variables

Based on studies by Ruijs et al. (2004), Jari and Fraser (2009) and Barret (2008), a farmer's use of agricultural technologies, extension contact, ownership of transport equipment, and household socio-economic characteristics are known to have an impact on output market participation. We also controlled for household socioeconomic and agricultural characteristics which might influence a smallholder household's food purchases. These characteristics include years of schooling of the household head, whether the primary caregiver completed primary education, presence of young children in the household, household size, household participation in off-farm work, household ownership of oxen and small livestock, and household ownership on non-agricultural assets (i.e., bicycle and motorcycle).

4. Empirical approach

This study aims to test the hypothesis that smallholder household food crop market participation and village food sales diversity score have a positive impact on household staple and non-staple food purchase diversity. Our analysis uses both descriptive analysis and an econometric approach. In the descriptive analysis, we provide frequencies and means to describe food group availability in rural market spaces. Smallholder output market participation, a key independent variable in this study, may be endogenous. The random error terms ε_{ait} and ε_{ait} in Eq. (1) and (2) may be correlated if the factors that determine market participation also influence our outcome variable. Ignoring such endogeneity might lead to model misspecification and hence biased estimates. Therefore, following previous studies (e.g.,Manda et al., 2021) we adopt an instrumental variables estimation technique (Wooldridge, 2010) with two-way fixed effects regression models in the first and second stages. This strategy also allows us to control for household unobserved and time-invariant heterogeneity, like smallholders' motivation which may affect their market orientation and food purchase diversity. We specify generic models as follows.

$$MP_{it} = \alpha_a + \delta_0 X_{it} + \delta_1 Z_{it} + \gamma_{ai} + \gamma_t + \varepsilon_{ait} \dots\dots (1)$$

$$FPDS_{it} = \alpha_b + \beta_0 MP_{it} + \beta_1 VDS_{it} + \beta_2 X_{it} + \gamma_{bi} + \gamma_t + \varepsilon_{bit} \dots\dots (2)$$

where MP_{it} in Eq. (1) represents output market participation of household *i* in year *t*. X_{it} is a vector of exogenous household characteristics while Z_{it} represents a vector of variables that determine market participation but have no direct influence on the food purchase diversity score. In Eq. (2), $FPDS_{it}$ represents food purchase diversity score of household *i* in year *t*; VDS_{it} signifies the village food sales diversity score of village/parish *i* in year *t*. The parameters of interest, β_0 measures the effect of a household's output market participation on FPDS while β_1 shows the effect of village sales diversity on FPDS. γ_i and γ_t are the household and time fixed effects. The random error terms in Eq. (1) and (2) are represented by ε_{ait} and ε_{bit}.

Eq. (1) and (2) are estimated using Roodman's (2011) Conditional Mixed Process (CMP) recursive framework. In this system, the endogenous explanatory variable in Eq. (2) (output market participation) is estimated as a dependent variable in Eq. (1). The CMP model produces unbiased estimates compared to the single equation model in Eq. (2) above if the *atanhrho* (a measure of the correlation between the error terms of the two equations) is statistically significant.

5. Results and discussion

5.1 Descriptive statistics

We describe the rural market food environment by assessing the food groups made available/marketed by smallholders within a village in each season/period. Table 2 shows that items in the staple food groups (Cereals, Plantain, Roots and Tubers and legumes and nuts) are the main foods sold in the communities in both regions. The least marketed food crops belong to the vitamin-A rich food groups. The dark leafy vegetables are particularly sold by less than 1% of smallholders. The percentage of smallholders marketing other fruits and other vegetables is less than 3% in the northern region and less than 7% in the western region. The trend of marketed output is similar for the animal products, with the exception of the flesh food group in the northern region. Of the 63% of smallholders that marketed flesh foods in the northern region, those

marketing live birds account for the greatest share. Animal flesh was marketed by about 20% of smallholders in the western region. About 16% of smallholders marketed eggs in the western region while about a half of this percentage in the northern region. Dairy products were marketed by about 10% and 7% of smallholders in the northern and western regions, respectively. However, smallholders who market milk likely account for the largest share of the dairy products in both regions. Clearly, availability of food in markets is skewed to staples and food group purchases seem to follow a similar trend. Table 2 shows that staples are dominant in food group purchases in both regions. Comparing demand of non-staples by region reveals that a higher supply is followed by a higher demand, holding other factors constant. For instance, in comparison to the northern, a higher percentage of smallholders in the western region supply "Other vegetables" and there is a greater demand in the western region for items in this food group. Similarly, the proportion of households who purchase animal flesh is higher in the northern region which has a higher percentage of smallholders who supply items in the food group.

Table 2: Food group sales/availability and food group purchase by region

	Household with marketed output %				**24-hour Consumption from purchases %**	
	Northern		Western		Northern	Western
	Season 1	Season 2	Season 1	Season 2		
Cereals, Plantain, Roots and Tubers	39.08	31.88	61.76	50.62	67.69	89.01
Legumes and Nuts	24.96	16.28	43.54	31.46	51.94	27.16
Amaranth leaves & other dark green leafy vegetables	0.75	0.99	0.53	0.35	4.29	1.43
Vitamin-A rich Vegetables &Fruit	1.56	1.32	1.37	0.89	0.81	0.60
Other Vegetables	2.18	2.13	6.77	3.22	18.96	22.09
Other Fruits	2.21	2.26	6.21	4.11	5.13	6.47
Dairy products	10.16		7.14		2.91	7.01
Meat, Fish, Poultry	63.14		19.99		13.91	8.54
Eggs	8.89		16.92		0.45	0.10
Observations	6,154	5,364	2,997	2,823	5,364	2,997

Notes: Seasons 1 and 2 correspond to the rain seasons between January and June and between July and December.

Table 3 shows descriptive statistics of the main independent variables. 71% and 59% of the households in our study sample sold at least one food crop in season 1and season 2, respectively. The proportion of these smallholders in season 2 increased significantly between 2012 and 2016. The low proportions of smallholders marketing most non-staple food items indicates that most sales outlets lack diversity or have a very low diversity score. Consistent with this, the Village food sales outlets had an average of about two food groups in each of the two seasons. With such a low VDS, market outlets are unlikely to deliver diet diversity to households. Unsurprisingly, the average FPDS is as low as two food groups. Both the VSDS and FPDS increased significantly over the survey years in the two seasons. On average smallholder households purchased 0.5 non-staple food groups. Summary statistics of control variables are provided in Table A1.

Table 3: Descriptive statistics for the dependent and key independent variables

	n	**Mean**	**SD**	**Min**	**Max**	**Difference in means Δ2012-2016[a]**

Sold at least one food crop						
Season 1	9,705	0.71	0.45	0	1	-0.0002 (0.011)
Season 2	8,669	0.59	0.49	0	1	0.085*** (0.012)
Number of food crop species sold						
Season 1	9,705	1.57	1.56	0	16	0.078** (0.040)
Season 2	8,669	1.13	1.33	0	11	0.223*** (0.036)
Share of marketed food crops						
Season 1	9,705	0.22	0.23	0	1	0.003 (0.006)
Season 2	8,669	0.19	0.24	0	1	0.045*** (0.006)
Village food sales diversity score						
Season 1	10,095	1.92	0.59	0.68	4	0.025** (0.015)
Season 2	10,095	1.58	0.54	0.48	4	0.055*** (0.014)
Food purchase diversity score	10,095	1.65	0.99	0	7	-0.216*** (0.025)
Non-staple purchase diversity score	10,095	0.46	0.71	0	5	-0.008 (0.018)

[a]Values are coefficients with standard errors in parenthesis. ***$p < 0.01$, **$p<0.05$

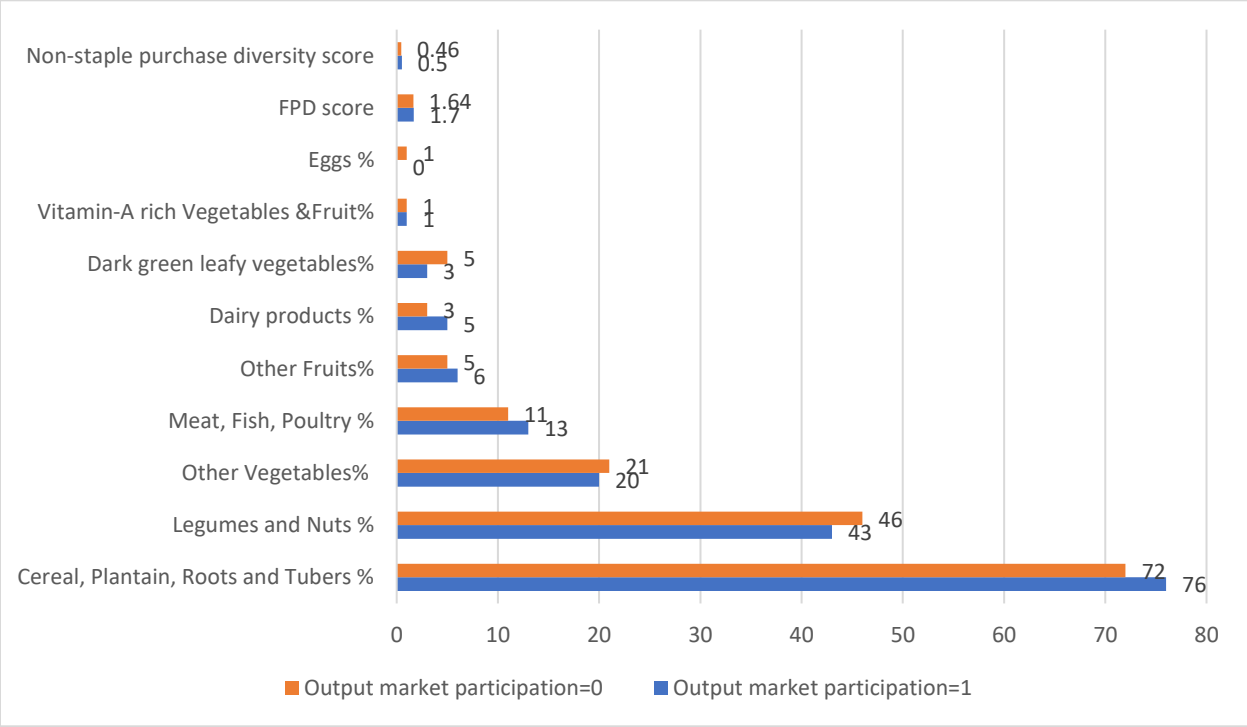

Figure 2: Percentage of smallholders purchasing different food groups by output market participation status

Figure 2 shows the proportions of output market participants and non-participants that purchase the different food groups that are also parallel to food groups sold by market participants. Apparent from Figure 2 is that purchase of staple food groups is dominant for both market participants and non-participants while the non-staple food groups are purchased by very small proportions of households regardless of the market participation status. This translates into a very low average non-staple food purchase diversity scores for both groups as shown in Figure 2. The low level of the non-staple purchase diversity is consistent with the low availability/supply of food items in

non-staple food groups shown in Table 2. On the other hand, the average FPDS is only 1.7 food groups for market participants and 1.6 food groups for non-participants signifying that households purchase food items from mainly two food groups made available by the largest proportion of suppliers.

5.2 Estimation results

5.2.1 Factors influencing smallholder output market participation

For brevity we present determinants of market participation in Season 1 while estimates for Season 2 are provided in the Appendix in Table A2. Table 4 presents the results of determinants of output market participation in Season 1. As expected the number of crops grown, use of production technologies, contact with an extension agent, ownership of transportation equipment (bicycle), ownership of a mobile phone and years of schooling of the household head have a positive impact on a smallholder household's market participation. On the other hand, household non-farm work, number of adults in the household and having improved storage facilities negatively impact output market participation. We also find that ownership of cash crop has a positive impact on food crop market participation.

Table 4: Determinants of output market participation in Season 1 (CMP model)

	Share of marketed food crops	**At least one food crop marketed**	**Number of food crops sold**
	dy/dx	dy/dx	dy/dx
Number of crop species grown	0.003** (0.001)	0.015*** (0.001)	0.064*** (0.001)
Years of schooling of household head	0.003*** (0.001)	0.001*** (0.0004)	0.001 (0.001)
Non-farm work	-0.057*** (0.006)	-0.019*** (0.002)	-0.039*** (0.005)
Number of adults	-0.002 (0.002)	-0.001* (0.001)	-0.002* (0.001)
Household owns mobile phone	0.037*** (0.006)	0.015*** (0.003)	0.027*** (0.005)
Household owns bicycle	0.039*** (0.006)	0.009*** (0.003)	0.004 (0.005)
Household owns motorcycle	0.010 (0.011)	-0.003 (0.005)	0.001 (0.010)
Household owns a cow	0.004 (0.007)	0.0002 (0.003)	0.001 (0.005)
Household owns goats/sheep	0.004 (0.006)	0.001 (0.002)	0.005 (0.004)
Household owns poultry	-0.009 (0.006)	-0.009*** (0.003)	-0.013*** (0.005)
Used integrated pest management	-0.014 (0.015)	-0.004 (0.006)	0.026** (0.013)
Applied inorganic fertilizer	0.043*** (0.011)	0.017*** (0.003)	0.060*** (0.008)
Used crop rotation	0.011* (0.007)	0.002 (0.003)	0.016*** (0.005)
Planted crops in rows	0.017*** (0.006)	0.009*** (0.003)	0.010** (0.005)
Used herbicides/pesticides	0.039*** (0.006)	0.015*** (0.002)	0.021***(0.005)
Used improved storage	0.008 (0.012)	-0.015** (0.006)	-0.035*** (0.011)
Extension contact	0.033*** (0.006)	0.011*** (0.002)	0.034*** (0.005)
Received credit	0.003 (0.007)	0.002 (0.003)	0.016*** (0.006)
Household owns cash crop	0.014** (0.006)	0.007*** (0.002)	0.012** (0.005)
Used improved seed	0.033*** (0.006)	0.006** (0.002)	0.001 (0.005)
Constant	0.152*** (0.011)	0.405*** (0.021)	-0.173*** (0 .060)
Household fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Households	3,583	3,583	3,583
Observations	7,064	7,064	7,064

Notes: These are marginal effects from the first stage of the cmp model. ***, **, and * denote level of statistical significance, at 1%, 5%, and 10% respectively. Standard errors clustered at the household level are reported in parentheses.

Table 5: Marginal effect of output market participation on food purchase diversity score

Independent variable	**Share of marketed food crops**		**At least one food crop marketed**		**Number of food crops sold**	
	(1)	(2)	(3)	(4)	(5)	(6)
	CMP model[a]	FE model[b]	CMP model[a]	FE model[b]	CMP model[a]	FE model[b]
Season 1 (January-June)						
Market participation	0.177***	0.042	0.030***	-0.009	0.004***	0.009
	(0.059)	(0.072)	(0.009)	(0.041)	(0.001)	(0.012)
Village sales diversity score	0.010***	-0.004	0.009***	0.009	0.008***	-0.010
	(0.002)	(0.046)	(0.002)	(0.050)	(0.002)	(0.047)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Households	3,583	3,254	3,583	3,254	3,583	3,254
Observations	7,064	7,079	7,064	7,079	7,064	7,079
atanhrho	-0.386***		-0.186***		-0.086***	
	(0.098)		(0.039)		(0.021)	
Season 2 (July-December)						
Market participation	0.161*	-0.125*	0.037***	0.044	0.008***	0.029*
	(0.084)	(0.075)	(0.009)	(0.042)	(0.002)	(0.015)
Village sales diversity score	0.010***	0.094*	0.006**	0.031	0.004*	0.019
	(0.003)	(0.055)	(0.002)	(0.062)	(0.002)	(0.056)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Households	3,550	3,193	3,550	3,193	3,550	3,193
Observations	8,187	6,370	8,187	6,370	8,187	6,370
atanhrho	-0.392***		-0.216***		-0.117***	
	(0.148)		(0.038)		(0.025)	

Notes: [a] estimates from the instrumental variable technique. [b] estimates from the single equation model. ***, **, and * denote level of statistical significance, at 1%, 5%, and 10% respectively. Standard errors clustered at the household level are reported in parentheses. Full model estimates are provided in the Appendix in Table A3 and Table A4.

5.2.2: Impact of output market participation and village sales diversity on food purchase diversity

In Table 5 we present marginal effects from the CMP model and the single equation model (linear FE model) that treats market participation as exogeneous. The statistically significant *atanhrho* in the CMP model indicates that output market participation is endogenous to FPDS. The results suggest that when we account for the endogeneity of output market participation, our main independent variables become statistically significant. The marginal effects in the first row of columns (1), (3) and (5) show that the share of marketed food output increases FPDS by 17 percentage points; sale of any share of at least one food crop increases FPDS by 3 percentage points; and increasing the number of food crops sold by 1 increases the FPDS by 0.4 percentage points in season 1. Marginal effects in the second row suggest that an increase in the VDS by five

food group increases the FPDS by up to 5 percentage points in season 1. Other determinants of FPDS include having an off-farm income source, education level of the household head and the caregiver and the household food security status (See Table A3 and A4 in the Appendix).

The results in the first row of Table 6 show that market participation does not impact non-staple purchase diversity in Season 1, even after considering the endogeneity of market participation. However, the effect is unclear in Season 2. The results in the second row show a positive effect of the VDS on non-staple purchase diversity in Season 1. VDS also has a positive impact on non-staple food purchase diversity in Season 2.

Table 6: Marginal effect of output market participation on non-staple purchase diversity score

Independent variable	**Share of marketed food crops**		**At least one food crop marketed**		**Number of food crops sold**	
	(1)	(2)	(3)	(4)	(5)	(6)
	CMP model[a]	FE model[b]	CMP model[a]	FE model[b]	CMP model[a]	FE model[b]
Season 1 (January-June)						
Market participation	0.185 (0.177)	0.043 (0.051)	-0.015 (0.031)	0.013 (0.029)	-0.003 (0.005)	0.010 (0.008)
Village sales diversity score	0.036*** (0.007)	0.0005 (0.031)	0.044*** (0.008)	5.44e-06 (0.034)	0.038*** (0.008)	-0.005 (0.032)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Households	3,583	3,254	3,583	3,254	3,583	3,254
Observations	7,064	7,079	7,064	7,079	7,064	7,079
atanhrho	-0.168 (0.131)		-0.024 (0.043)		0.0004 (0.022)	
Season 2 (July-December)						
Market participation	0.174 (0.311)	0.033 (0.056)	0.071 (0.064)	0.047 (0.031	0.014 (0.015)	0.029*** (0.011)
Village sales diversity score	0.033*** (0.008)	0.018 (0.041)	0.078*** (0.020)	-0.011 (0.050)	0.055*** (0.019)	-0.021 (0.042)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Households	3,550	3,193	3,550	3,550	3,550	3,550
Observations	8,187	6,370	8,187	6,370	8,187	6,370
atanhrho	0.096 (0.240)		-0.092** (0.042)		-0.0180 (0.026)	

Notes: [a] estimates from the instrumental variable technique. [b] estimates from the single equation model. ***, **, and * denote level of statistical significance, at 1%, 5%, and 10% respectively. Standard errors clustered at the household level are reported in parentheses. Full model estimates are provided in the Appendix in Table A5.

6. Conclusion and policy implications

In this paper we have used the food environment framework to understand the effect of the market food environment on dietary behavior. We argue that market access per se does not translate to diet diversity of households or individuals. When markets become accessible, a diversity of food needs to be available in the markets to influence purchase diversity. Our results show that smallholder output market participation, which conceptually increases a smallholder household's

market accessibility and purchasing power, has a positive impact on FPDS but does not impact non-staple purchase diversity, probably due to lack of or low availability of non-staples in sales outlets. But more importantly, we find that village food sales diversity score has a positive impact on non-staple purchase diversity. These findings imply that smallholders can be supported to increase the supply of non-staples in sales outlets in their communities. The findings in this paper suggest that such support to smallholders could be inform of subsidised inputs (fertilizer, improved seed), farmer training and extension contact. A limitation of this study is that, due to the limitation inherent in our data, we were unable to provide a disaggregated analysis based on lean periods and periods of plenty. Nonetheless, our study contributes to the ongoing discussions on the role of food environments in dietary behavior.

References

Appendix

Table A1: Descriptive statistics of selected variables used in the study

Variable	N	Pooled	2012	2014	2016
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Crop species grown (Jan-Jun)	9,151	4.17 (2.28)	4.32 (2.34)	3.67 (1.95)	4.45 (2.42)
Crop species grown (Jul-Dec)	8,187	3.52 (2.21)	3.73 (2.12)	2.56 (1.74)	3.99 (2.40)
Non-farm work (0/1)	9,151	0.79 (0.41)	0.74 (0.44)	0.83 (0.37)	0.82 (0.39)
Years of schooling of household head	9,151	6.23 (3.37)	6.32 (3.40)	6.15 (3.38)	6.19 (3.33)
Main woman completed primary education (0/1)	8,017	0.22 (0.41)	0.22 (0.41)	0.21 (0.41)	0.22 (0.41)
Number of adults (>12 years)	9,136	3.32 (1.73)	2.90 (1.61)	3.42 (1.69)	3.71 (1.79)
Share of children under five	7,922	0.29 (0.14)	0.32 (0.14)	0.29 (0.14)	0.26 (0.13)
Household size	9,151	6.60 (2.49)	6.03 (2.57)	6.78 (2.30)	7.11 (2.42)
Household owns mobile phone (0/1)	9,151	0.56 (0.50)	0.52 (0.50)	0.57 (0.50)	0.62 (0.49)
Household owns bicycle (0/1)	9,151	0.53 (0.50)	0.54 (0.50)	0.54 (0.50)	0.50 (0.50)
Household owns motorcycle (0/1)	9,151	0.06 (0.23)	0.04 (0.20)	0.06 (0.23)	0.07 (0.26)
Household owns a cow (0/1)	9,151	0.28 (0.45)	0.24 (0.43)	0.29 (0.46)	0.31 (0.46)
Household owns goats/sheep (0/1)	9,151	0.52 (0.50)	0.52 (0.50)	0.52 (0.50)	0.53 (0.50)
Household owns poultry (0/1)	9,151	0.68 (0.47)	0.66 (0.47)	0.68 (0.47)	0.70 (0.46)
Used integrated pest management (0/1)	9,151	0.03 (0.17)	0.04 (0.20)	0.03 (0.17)	0.02 (0.14)
Applied inorganic fertilizer (0/1)	9,151	0.04 (0.20)	0.03 (0.17)	0.05 (0.21)	0.06 (0.23)
Used crop rotation (0/1)	9,151	0.81 (0.39)	0.85 (0.35)	0.83 (0.38)	0.74 (0.44)
Planted crops in rows (0/1)	9,151	0.68 (0.47)	0.69 (0.46)	0.64 (0.48)	0.70 (0.46)
Used herbicides/pesticides (0/1)	9,151	0.23 (0.42)	0.15 (0.36)	0.21 (0.40)	0.33 (0.47)
Used improved storage (0/1)	9,151	0.06 (0.23)	0.10 (0.30)	0.02 (0.14)	0.04 (0.19)
Extension contact (0/1)	9,151	0.22 (0.41)	0.33 (0.47)	0.17 (0.38)	0.14 (0.35)
Received credit (0/1)	9,151	0.18 (0.39)	0.10 (0.31)	0.14 (0.35)	0.31 (0.46)
Household owns cash crop (0/1)	9,151	0.31 (0.46)	0.38 (0.48)	0.31 (0.46)	0.24 (0.43)
Household used improved seed (0/1)	9,151	0.26 (0.44)	0.30 (0.46)	0.23 (0.42)	0.26 (0.44)

Table A2: Determinants of output market participation in Season 2 (July-December) (CMP model)

	Share of marketed food crops	At least one food crop marketed	Number of food crops sold
	dy/dx	dy/dx	dy/dx
Number of crop species grown	0.005*** (0.001)	0.029*** (0.001)	0.069*** (0.002)
Years of schooling of household head	0.002** (0.001)	0.001 (0.001)	-0.0001 (0.001)
Non-farm work	-0.057*** (0.008)	-0.025*** (0.004)	-0.043*** (0.006)
Number of adults	-0.005** (0.002)	-0.004*** (0.001)	-0.003* (0.002)
Household owns mobile phone	0.038*** (0.007)	0.026*** (0.005)	0.038*** (0.006)
Household owns bicycle	0.031*** (0.007)	0.001 (0.005)	-0.006 (0.006)
Household owns motorcycle	0.018 (0.014)	0.007 (0.008)	0.001 (0.012)
Household owns a cow	0.015* (0.008)	0.002 (0.005)	0.003 (0.007)
Household owns goats/sheep	0.007 (0.007)	0.003 (0.004)	0.007(0.006)
Household owns poultry	-0.011 (0.007)	-0.009* (0.005)	-0.019*** (0.006)
Used integrated pest management	-0.029* (0.017)	0.006 (0.010)	0.032** (0.016)
Applied inorganic fertilizer	0.041*** (0.015)	0.019** (0.008)	0.056*** (0.012)
Used crop rotation	0.009 (0.008)	0.004 (0.005)	0.006 (0.007)
Planted crops in rows	0.009 (0.007)	0.004 (0.005)	0.006 (0.006)
Used herbicides/pesticides	0.040*** (0.008)	0.023*** (0.004)	0.025*** (0.007)

Used improved storage	-0.014 (0.016)	-0.025*** (0.010)	-0.051*** (0.014)
Extension contact	0.051*** (0.008)	0.034*** (0.004)	0.054*** (0.006)
Received credit	-0.006 (0.008)	0.002 (0.005)	-0.005 (0.007)
Household owns cash crop	-0.008 (0.009)	-0.002 (0.004)	-0.017*** (0.006)
Used improved seed	0.026*** (0.008)	0.004 (0.004)	0.005 (0.006)
Constant	0.170*** (0.012)	0.364*** (0.023)	0.182*** (0.055)
Household fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Households	3,550	3,550	3,550
Observations	6,359	6,359	6,359

Notes: These are marginal effects from the first stage of the cmp model. ***, **, and * denote level of statistical significance, at 1%, 5%, and 10% respectively. Standard errors clustered at the household level are reported in parentheses.

Table A3: Marginal effect of output market participation on food purchase diversity (January-June)

Independent variable	**Share of marketed food crops**		**At least one food crop marketed**		**Number of food crops sold**	
	cmp model[a]	FE model[b]	cmp model[a]	FE model[b]	cmp model[a]	FE model[b]
Market participation	0.177*** (0.059)	0.042 (0.072)	0.030*** (0.009)	-0.009 (0.041)	0.004*** (0.001)	0.009 (0.012)
Village sales diversity score	0.010*** (0.002)	-0.004 (0.046)	0.009*** (0.002)	0.009 (0.050)	0.008*** (0.002)	-0.010 (0.047)
Off-farm income source	0.043*** (0.007)	0.168*** (0.039)	0.029*** (0.004)	0.167*** (0.039)	0.026*** (0.003)	0.166*** (0.039)
Years of schooling of HH head	0.001* (0.001)	0.012 (0.011)	0.001*** (0.000)	0.012 (0.011)	0.002*** (0.0004)	0.012 (0.011)
Caregiver/mother completed primary education	0.017*** (0.003)	0.084 (0.067)	0.014*** (0.003)	0.085 (0.067)	0.014*** (0.003)	0.085 (0.067)
Share of children under 5	0.010 (0.012)	-0.177 (0.157)	0.007 (0.010)	-0.177 (0.157)	0.007 (0.010)	-0.175 (0.157)
Household size	0.000 (0.001)	0.009 (0.012)	0.0001 (0.001)	0.009 (0.012)	-0.0001 (0.001)	0.009 (0.012)
Food secure HH	0.007* (0.004)	0.016 (0.042)	0.006* (0.003)	0.017 (0.042)	0.005* (0.003)	0.016 (0.042)
HH owns bicycle	-0.004 (0.004)	-0.043 (0.046)	0.003 (0.003)	-0.042 (0.046)	0.004 (0.003)	-0.044 (0.046)
HH owns motorcycle	0.023*** (0.005)	0.037 (0.081)	0.021*** (0.004)	0.038 (0.081)	0.020*** (0.004)	0.038 (0.080)
HH owns a cow	-0.002 (0.004)	-0.042 (0.046)	-0.001 (0.003)	-0.042 (0.046)	-0.001 (0.003)	-0.043 (0.046)
HH owns goats	0.005 (0.003)	0.050 (0.035)	0.004* (0.003)	0.050 (0.035)	0.005* (0.002)	0.049 (0.035)
HH owns poultry	0.004 (0.003)	0.012 (0.039)	0.003 (0.003)	0.009 (0.039)	0.003 (0.003)	0.012 (0.039)
Constant	0.706*** (0.113)	1.386*** (0.148)	0.800*** (0.093)	1.378*** (0.148)	.961*** (0.083)	1.392*** (0.148)
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Households	3,583	3,254	3,583	3,254	3,583	3,254
Observations	7,064	7,079	7,064	7,079	7,064	7,079

atanhrho	-0.386***		-0.186***		-0.086***	
	(0.098)		(0.039)		(0.021)	

Notes: [a] estimates from the instrumental variable technique. [b] estimates from the single equation model. ***, **, and * denote level of statistical significance, at 1%, 5%, and 10% respectively. Standard errors clustered at the household level are reported in parentheses.

Table A4: Marginal effect of output market participation on food purchase diversity (July-December)

Independent variable	**Share of marketed food crops**		**At least one food crop marketed**		**Number of food crops sold**	
	cmp model[a]	FE model[b]	cmp model[a]	FE model[b]	cmp model[a]	FE model[b]
Market participation	0.161*	-0.125*	0.037***	0.044	0.008***	0.029*
	(0.084)	(0.075)	(0.009)	(0.042)	(0.002)	(0.015)
Village sales diversity score	0.010***	0.094*	0.006**	0.031	0.004*	0.019
	(0.003)	(0.055)	(0.002)	(0.062)	(0.002)	(0.056)
Off-farm income source	0.038***	0.161***	0.027***	0.162***	0.025***	0.161***
	(0.008)	(0.042)	(0.004)	(0.042)	(0.004)	(0.042)
Years of schooling of HH head	0.001**	0.007	0.001***	0.007	0.001***	0.007
	(0.001)	(0.012)	(0.0004)	(0.012)	(0.0004)	(0.012)
Caregiver/mother completed primary education	0.018***	0.135**	0.015***	0.135**	0.015***	0.134*
	(0.003)	(0.068)	(0.003)	(0.068)	(0.003)	(0.068)
Share of children under 5	0.005	-0.389**	0.004	-0.387**	0.004	-0.385**
	(0.012)	(0.176)	(0.011)	(0.176)	(0.010)	(0.176)
Household size	0.0003	0.014	0.000	0.015	0.000	0.015
	(0.001)	(0.013)	(0.001)	(0.013)	(0.001)	(0.013)
Food secure HH	0.006	0.031	0.005	0.027	0.005	0.026
	(0.004)	(0.046)	(0.003)	(0.046)	(0.003)	(0.046)
HH owns bicycle	-0.001	-0.011	0.003	-0.015	0.003	-0.017
	(0.004)	(0.049)	(0.003)	(0.049)	(0.003)	(0.048)
HH owns motorcycle	0.024***	-0.004	0.021***	-0.005	0.021***	0.0005
	(0.005)	(0.085)	(0.004)	(0.085)	(0.004)	(0.085)
HH owns a cow	-0.004	-0.035	-0.001	-0.035	-0.001	-0.037
	(0.004)	(0.051)	(0.003)	(0.051)	(0.003)	(0.051)
HH owns goats	0.004	0.044	0.004	0.043	0.004	0.040
	(0.003)	(0.039)	(0.003)	(0.039)	(0.003)	(0.039)
HH owns poultry	0.003	-0.034	0.003	-0.021	0.003	-0.020
	(0.004)	(0.042)	(0.003)	(0.042)	(0.003)	(0.042)
Constant	0.758***	1.335***	.868***	1.373***	1.019***	1.387***
	(0.153)	(0.153)	(0.094)	(0.154)	(0.085)	(0.154)
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Households	3,550	3,193	3,550	3,193	3,550	3,193
Observations	8,187	6,370	8,187	6,370	8,187	6,370
atanhrho	-0.392***		-0.216***		-0.117***	
	(0.148)		(0.038)		(0.025)	

Notes: [a] estimates from the instrumental variable technique. [b] estimates from the single equation model. ***, **, and * denote level of statistical significance, at 1%, 5%, and 10% respectively. Standard errors clustered at the household level are reported in parentheses.