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The effects of market-oriented farming on living standards, nutrition, and informal sharing arrangements of smallholder farmers: the case of African indigenous vegetables in Kenya

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Abstract

The shift from subsistence to more market-oriented agriculture is viewed as essential to increase smallholder farmers' welfare. However, its impact on farmers' nutrition and informal sharing arrangements and associated solidarity within African farming communities remains uncertain. To analyse these trade-offs, we study the growing commercialization of African indigenous vegetables (AIV) in Kenya. These vegetables are an essential component of local diets in rural areas but also of informal sharing arrangements that provide access to food outside of markets. This article combines quantitative data from a 2016–2022 panel survey of farmers with qualitative data from focus group discussions. Results based on household fixed-effects models show a significant increase in households' non-food expenditures due to selling AIV. The results suggest that selling AIV did not negatively affect nutrition outcomes but did not improve them either. Informal AIV sharing between households decreased further with growing market participation. Panel data models indicate, however, inconsistent and insignificant changes in associated solidarity indicators. We attribute this to the multiple and sometimes opposing effects of market-oriented farming on solidarity, as revealed by focus group discussions. While some farmers perceive reduced solidarity due to less informal AIV sharing, others perceived this traditional solidarity to be partially forced. Other forms of social interaction have also emerged, such as cooperatives and more intensive knowledge sharing. Despite concerns about the loss of informal sharing and community solidarity and limited improvements in nutrition outcomes, the tangible income gains generated by selling AIV are likely to foster further growth in the AIV sector.

Keywords Smallholder farmers · African indigenous vegetables · Commercialization · Mixed methods

1 Introduction

Sub-Saharan Africa's (SSA) smallholder agriculture remains saddled with a significant number of families living in poverty and experiencing malnutrition. This issue has received intensified attention on a global scale, with recent years witnessing an upward trajectory in absolute numbers of individuals suffering from malnutrition (FAO et al., 2022). Accelerating the transition from subsistence to more market-oriented agriculture in rural areas of SSA could be a strategic approach to provide farmers with access to new income sources, leading also to a potential improvement in local food security. Several studies show positive impacts of market-oriented agriculture on the income of smallholder farmers (Krause et al., 2019; Muriithi & Matz, 2015; Ogutu et al., 2020; van Asselt & Useche, 2022). However, the shift to more market-oriented agriculture could also involve

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significant trade-offs. Market participation can make farmers more dependent on agricultural output markets and prices or detrimental contract arrangements—and can hence aggravate pre-existing vulnerabilities (Dolan, 2001; Gironde et al., 2021; Njuki et al., 2011; Park & Maffii, 2017; Prügl et al., 2021). The empirical effects of an increasing market participation on smallholder farmers' nutrition-related outcomes are also in general ambiguous with some studies reporting positive (Kirk et al., 2018; Ogutu et al., 2020), some no effects or mixed results (Carletto et al., 2017; Chegere & Kauky, 2022), and some even negative effects (van Asselt & Useche, 2022). These negative effects could be even more pronounced if nutritionally important subsistence crops are increasingly sold on markets. Beyond nutrition, important informal insurance mechanisms can also deteriorate. In rural communities in SSA, individuals regularly share a significant portion of their resources with members of their social networks due to strong social norms (Baland et al., 2016; Banerjee et al., 2021; Ligon & Schechter, 2012), and also subsistence crops without commercial value were often shared within social networks (Brückner, 2020; Holmelin, 2021). To understand the shift from subsistence to more market-oriented agriculture from a development perspective focused on food security, holistic analyses of these different effects are needed.

In this article, we examine the effect of selling leafy African indigenous vegetables (AIV) on local markets in Western Kenya. AIV are traditionally part of the local diet in Kenya and include species such as vegetable amaranth (*Amaranthus spp.*), African nightshade (*Solanum scabrum*), spider plant (*Cleome gynandra*) and cowpea leaves (*Vigna unguiculata*). AIV have high nutritional value and are an important part of the diet in rural Kenya (Bokelmann et al., 2022; Gido et al., 2017; Krause et al., 2019). In addition, AIVs are also an integral part of community social interaction as the vegetables are often harvested and cooked in groups. They also have strong socio-cultural functions and have also traditionally been used as gifts between households (Brückner, 2020; Musotsi et al., 2018). However, the shift from being mere subsistence crops to more market-oriented cropping systems might eventually lead to reduced resource sharing within social networks and alter perceptions of solidarity within farming communities.

Selling AIV on markets is a rather recent phenomenon compared to other crops in SSA. Due to the influence of Western culture and markets, exotic vegetables such as kale (*Brassica oleracea var. acephala*) dominated the commercial vegetable market (Brückner & Caglar, 2016). For decades, the more affluent urban population preferred exotic vegetables and the beneficial health effects of AIV were also not widely recognized (Gido et al., 2017). In rural areas, most households had free access to AIV, as they grew as weeds along with other crops and were freely shared among

households. Although aggregate data are not available, case studies suggest that market demand of AIV has been increasing since the mid-1990s (Abukutsa-Onyango, 2007; Bioversity International and EIARD, 2013; von Braun et al., 2023). The trend is driven by demand-side factors, including a growing urban population that still prefers the traditional local diet from their rural homes, increasing awareness of the positive health effects of AIV in term of micronutrient supply, and campaigns by various stakeholders to promote AIV consumption (Bioversity International and EIARD, 2013). On the supply side, high climate resilience and relatively low dependence on external inputs for AIV cultivation such as fertilizer and pesticides, as well as the associated increase in farmers' household income, promoted AIV cultivation and marketing (Bokelmann et al., 2022; Krause et al., 2019; Shackleton et al., 2009). Overall, the growing demand led to increased integration of AIV into developed value chains, including restaurants, supermarkets, and hotels (Bokelmann et al., 2022; Gido et al., 2016).

To analyse the potential effects of selling AIV on income, which we proxy by expenditure data, nutritional intake, resource sharing, and solidarity within farming communities, we use both quantitative data from a panel survey of smallholder farmers conducted between 2016 and 2022 in Kenya and qualitative data from focus group discussions (FGD) conducted with farmers in 2022. We combine both sets of data to describe broader consequences of selling AIV that go beyond income increases. Our contribution to the literature is to not only consider income effects, but also to analyse the nutrition-related impacts of selling AIV on markets for local nutritional intake and to reflect on how farmers perceive and experience changes in resource sharing and solidarity within their networks. Few studies investigate the effect of the shift from subsistence to more market-oriented agriculture on resource sharing and solidarity. There are also few studies examining the impact of selling horticultural products on farm household income and nutrition, and the literature is sparse, particularly for AIV (Krause et al., 2019). Despite limited empirical evidence of their importance to the rural economy and food security, AIV are often portrayed as essential for ensuring sustainable and resilient food systems in Western Kenya due to the positive health effects of consumption (Odongo et al., 2018), high climate resilience, and limited reliance on external inputs such as seeds and fertilizer (Bokelmann et al., 2022).

2 Conceptual framework

We study the degree to which agricultural production of smallholders is sold on markets, hence a shift from subsistence to more market-oriented farming. Researching the impacts of these transitions on economic development and

nutrition has a long history in development studies (von Braun & Kennedy, 1994). With a focus on empirical analysis, recent studies examine crop commercialization in smallholder farming systems in SSA and its effects on income, nutritional intake and gender relations (Carletto et al., 2017; Krause et al., 2019; Muriithi & Matz, 2015; Ogutu et al., 2020; Sibhatu et al., 2015). The focus of the literature on market-oriented agriculture is often on the adoption of cash crops. Horticultural products, which are in general more difficult to commercialize due to challenges in postharvest management, are also covered to some extent, with Krause et al. (2019) focusing on AIV in Kenya and Muriithi and Matz (2015) on vegetables in Kenya in general. In the following, we describe the transmission channels of selling AIV on income, nutrition, and resource sharing and solidarity among smallholder farmers.

The transmission mechanisms on income, nutrition, gender relations and resource sharing are disaggregated as follows in the literature (van Asselt & Useche, 2022).

Income/expenditure effect Increasing the share of agricultural production sold on markets can increase the total income of smallholder farmers through cash income, but also through efficiency gains from specialization and shifts in labour time allocation. The additional disposable income can be used for non-food expenditures but also more and more diverse and healthier food. However, also potentially health endangering diets such as convenience food could be purchased.

Subsistence effect As selling the agricultural production on markets increases, subsistence consumption of households decreases, assuming constant yields and acreage. Depending on the nutritional value of each crop, this could have a negative impact on nutrition. In addition, farmers' production practices could change, as market-oriented farming may provide incentives for the adoption of new technologies and further specialization. Therefore, as market participation and specialization increase, production diversity could decrease, which in turn could affect dietary diversity (Sibhatu et al., 2015).

Gender effect If the subsistence crop has been traditionally under the control of women, increasing market participation and associated income increases could empower women. This could even further increase households' food expenditures, as the literature tends to support the notion that women spend more of their disposable income on food compared to men (Quisumbing et al., 1996). However, increasing demand and commercialization could provide an incentive for men to involve in cultivation and marketing of former subsistence crops. In addition, this could induce them to retain some of the profits for themselves that would otherwise have been

in the hands of women. Besides, if market-oriented farming involves additional work for women and men's involvement do not offset the increase in working hours, women will face an increasing labour burden. Women may hence have less time for cooking and preparing food in general, in particular nutritious but time-intensive dishes (Musotsi et al., 2018). However, a recent study did not find any significant association between on-farm work and child nutrition (Debela et al., 2021).

Resource sharing effect While it is plausible that market-oriented farming could impact informal resource sharing within the relevant sector, the available evidence does not allow us to draw any conclusions on the specific direction of this effect. In general, the literature on the effects of market-oriented farming and intra-community interaction and their impact on sharing in the context of SSA is rather limited. Most literature has so far focused on the interaction between formal and informal insurance mechanisms including mutual sharing (Banerjee et al., 2021; Chuang & Schechter, 2015). In the case of commercialization and smallholder farming, Gebru et al. (2021) document adverse impacts of commercialization on traditional practices of resource exchange. For many groups in SSA, resource sharing remains however a strong norm (Bernard et al., 2010; Olié, 2022). Outside of SSA, some specific studies exist for hunter-gather societies in the Amazonas region. Donders and Barriocanal (2020) conclude that market participation by these indigenous groups does not pose an immediate threat to resource sharing, drawing on the heterogeneous findings in the literature. Among these studies, Gurven et al. (2015) conclude that market integration does not necessarily substitute traditional sharing networks in Bolivia, but instead can often expand the social capital of indigenous groups. Henrich et al. (2005) also conclude, based on cross-country experimental data, that societies with higher levels of market participation exhibit more generous social behaviour and share more.

Solidarity effect We expect ambiguous effects on community solidarity. Perceptions and experiences of smallholder solidarity are influenced by interactions at the community level that produce different intensities of solidarity, which in turn promote resource sharing. We hypothesize that these patterns of interaction may change as a result of new innovations and practices, such as selling AIV. We assume that community solidarity is both an outcome and a determinant of an individual's propensity to share resources. However, if resource sharing becomes more expensive because of changes in associated values, such as market prices, then less resource sharing could also affect perceptions of solidarity more generally. On the other hand, some literature suggests that sharing in-kind or cash is often a significant burden for the sharing household or firm (Grimm et al., 2013, 2017;

Olié, 2022) and that forced solidarity can even deter individuals from investing (Grimm et al., 2017). For example, in Senegal Boltz et al. (2019) observed that individuals reduce the share of profits they pass on to kin by almost a quarter when they have the option to hide their real income. Commercialized agriculture, while not mutually exclusive, often works against traditional norms of sharing and solidarity. We therefore hypothesize that not all individuals will perceive that community solidarity is diminishing as the commercialization of formerly shared products increases, as some individuals perceived the traditional sharing mechanism as unfair exploitation of their labour.

3 Methodology

3.1 Data

Our study uses household-level data on local farms collected in two counties in Western Kenya. The first rounds of surveys were repeated in 2014, 2015, and 2016 as part of a larger interdisciplinary research project (HORTINLEA) (Kebede et al., 2018). However, the module on solidarity was not included until 2016. The module on community solidarity builds on questions designed for a fragility exposure index (Baliki et al., 2022). To obtain a representative sample, a multi-stage sampling procedure was used. In the first stage, sub-counties and division areas were purposively selected while in the second stage, wards were randomly selected. Farm households in the wards were again randomly selected. Sampling was conditional on households consuming, marketing, or producing AIV. Surveys were conducted from September to October using structured questionnaires. In 2022, as part of a different research project, a follow-up survey was conducted in two counties (Kisii and Kakamega). The survey targeted 396 households and included the same modules on solidarity, but also on household consumption and agricultural production as in 2016. The interviews were conducted in person by one enumerator in the local language. In total, 363 households were successfully enumerated. The attrition rate was 9% as some households dissolved due to deceased members and some migrated to urban areas. To track long-term changes in market-oriented farming and nutrition, a panel was created with data from 2016 to 2022. In total, complete panel data were available for 362 households.¹

In addition to household-level data, 20 FGD were conducted in 10 communities in the counties of Kisii and Kakamega, from January to February 2022 (Hackfort et al., 2024). Participant selection in Kisii was facilitated by the

County Agricultural Extension Officers, while in Kakamega, it was coordinated through the Butere-Mumias Traditional Vegetables Cooperative Society. Key sub-counties involved in AIV production were identified, and lists and contact information of households and groups engaged in AIV production were provided. From these lists, potential interview respondents were randomly selected and invited to participate. Each group comprised 8–10 individuals, segregated by gender, and sessions were held in the same regions and communities as the quantitative survey. All interviews were recorded in the local language and translated into English by the same enumerators who conducted the interviews. In addition to questions centred around nutritional intake and income, the interviews explicitly addressed the effects of AIV commercialization on resource sharing and solidarity. The qualitative data serves to gather additional insights in the effects of AIV commercialization on solidarity to complement the quantitative results.

3.2 Econometric modelling and coding strategy

Establishing a causal effect between selling AIV and nutrition outcomes, household expenditures, and solidarity presents two challenges. First, unobserved characteristics of the households or respondents, such as personal traits or agricultural conditions, may be correlated with both selling AIV and our outcome variables. To address bias due to unobserved time-invariant variables, we use household-level fixed effects (FE) models to control for time-invariant farming conditions and other socioeconomic characteristics of the households while reporting the random-effects (RE) model results as an additional robustness check.² Second, selling AIV directly affects income, but the causal relationship could also be the reverse in the case that rising incomes increase market participation. While we cannot control for reverse causality in our models, we will use qualitative data to support our reasoning about the direction of the effects. Our model is specified as follows:

$$Y_{it} = \beta_o + \beta_1 C_{it} + \beta_2' X_{it} + \gamma_t + \mu_i + \epsilon_{it}, \quad (1)$$

where Y_{it} is our outcome variable, i.e., total non-food consumption expenditure per capita, food consumption expenditure per capita, AIV consumption in kg per capita and household dietary diversity by household i in year t . We use a household dietary diversity score (HDDS) that counts the number of different food groups consumed by the household up to a maximum of 12 food groups. C_{it} is the share of AIV production sold by household i in year

¹ One household in 2016 had missing data across multiple sections.

² Estimating a linear model including both unit fixed effects and time fixed effects in ordinary least squares estimation is often called “two-way fixed effects” (TWFE) model.

t . X_{it} is a vector of household-level control variables such as age, gender, education, marital status of household head, number of household members, number of adult household members, farm size, asset index, number of employed household members, and off-farm business activities. The year FE γ_i control for year-specific shocks. The household-level FE μ_i control for time-invariant differences across households, while ϵ_{it} is the error term.

A qualitative data analysis (QDA) using the software MAXQDA was conducted for the FGDs. All transcripts have been deductively coded by a team of up to three researchers using categories derived from a social cohesion framework such as perceived fairness, social networks, and solidarity (Fiala & Jacob, 2023). In the framework, social cohesion is enabled or constrained through macro-level developments, mediated through social structures and institutions, performed through the interactions of groups and communities, and in the end perceived and experienced at the individual level. In our interviews, we collected data on perceptions and experiences at the individual level. We further assume that perceptions and experiences of social cohesion at the individual level, which includes the perception of solidarity, can improve, remain stable or deteriorate. The interactions within a community or group are shaped by the individuals who perceive and experience the quality of the interactions and interactions at the level of communities can re-produce the same relational patterns of low or high levels of social cohesion. For our study, we assume that patterns of interaction are affected by technological and institutional changes including commercialization and hence produce new patterns of perceptions and experiences of social cohesion.

4 Results

4.1 Descriptive results from quantitative surveys

National data points to an increasing importance of AIV in the Kenyan market. For instance, the production area of African nightshade in Kenya increased from 4285 ha in 2016 to 5917 ha in 2020, and the production area of spider plants increased from 2854 to 3949 ha during the same period (Horticultural Crops Directorate, 2020). The available evidence from the literature suggests that this is partly driven by rising demand on markets and the commercialization of AIV (Abukutsa-Onyango, 2007; Bioversity International and EIARD, 2013; Gido et al., 2016; Bokelmann et al., 2022). This is also corroborated by the FGDs and our quantitative data. Figure 1 demonstrates that over the six-year period, AIV were increasingly purchased rather than grown on the farm for consumption. In particular for spider plant but also for African nightshade, purchases are quite common. A total of 144 out of 362 farm households also expanded their AIV area from 2016 to 2022. Yet, we find that the overall share of households selling AIV in our sample actually declined (Fig. 2). In addition, the share of AIV production sold decreased statistically significantly from 39 to 33% between 2016 and 2022. We attribute this, in part, to the dissolution of a major AIV cooperative in one of the counties surveyed which was important to early adopters of AIV commercialization. Panel data models show that households in AIV cooperatives sell 10% more of their produce (Table A1 in the Appendix). In addition,

Fig. 1 Sources of AIV for farm households' consumption. The remaining source of farm households' AIV consumption is their own production which is not listed in the figure

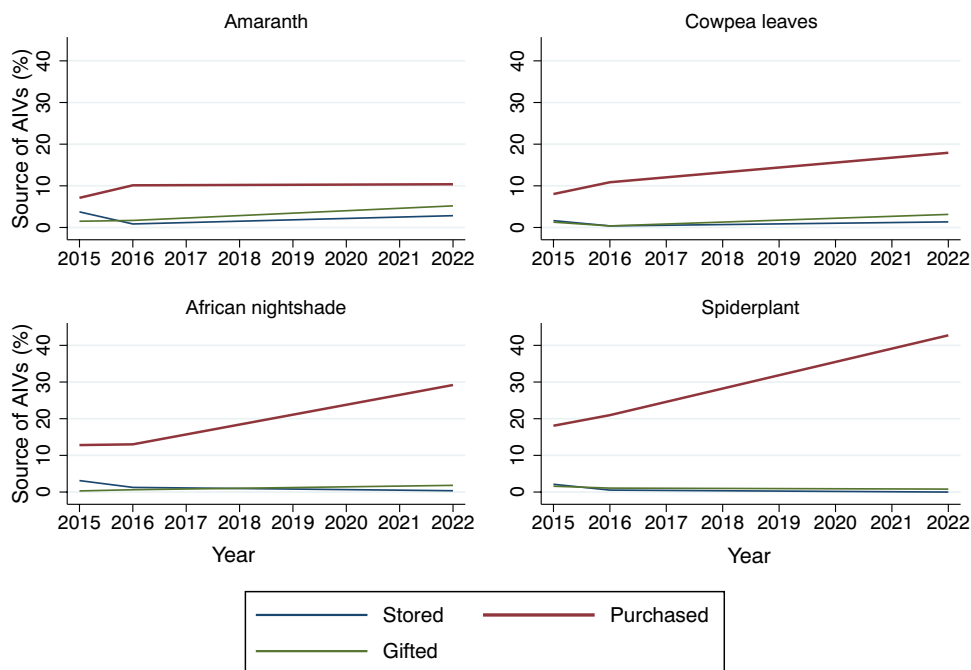
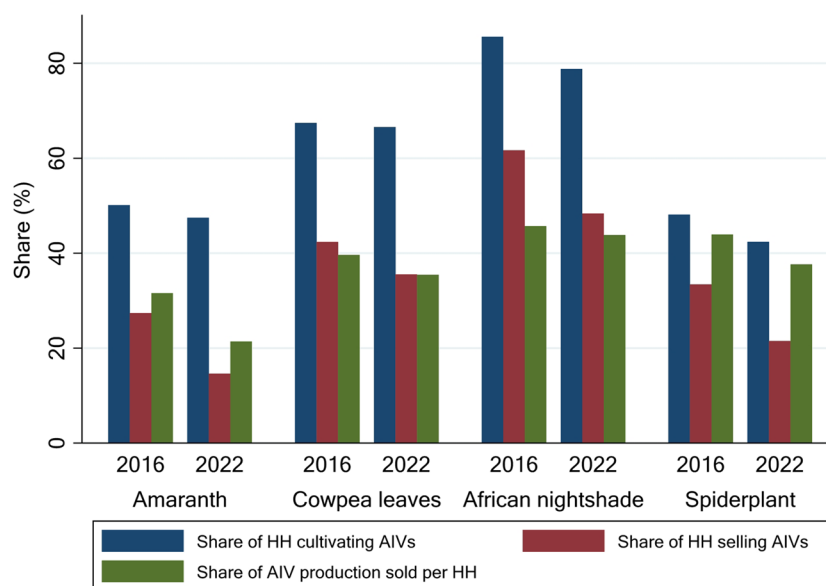


Fig. 2 Share of farm household producing and selling AIVs. Share of AIV production sold per household (HH) is conditional on cultivating AIVs



the overall increase of selling AIV on markets in the region may also have reduced the individual share of AIV sales of the early adopters of AIV commercialization that we have sampled due to the increased competition. We observe not only a decrease in sales, but also that the AIV cultivation area seems to have decreased (Figure A1 in the Appendix). This may have led to a decrease in the overall availability of AIV for home consumption at the household level and an increased reliance on purchasing AIV. We also observe that receiving AIV as gift remained marginal for household consumption. Contrary to the shifts in selling AIV, our descriptive results in Fig. 1 show that the share of households cultivating AIV is stable over time (i.e. from 2016 to 2022).

The process of commercialization is also driven by changing preferences. The quotes show that AIV are consumed for both cultural reasons which is confirmed in various quotes, however, also health awareness in interplay with new emerging diseases due to changing consumption patterns but also pandemics could play an important role with the latter one become increasingly important over time.

... we are used to eating AIV. It is our culture. [Men from Kisa West, Pos. 285]

Today many people have developed certain diseases and have returned to consume indigenous vegetables, for example, African vine spinach was never sold before but today we are selling it. [Women from Magenche Ward, Pos. 89]

It [AIV consumption] prevents diseases, for example, COVID 19. [Women from Masimba Ward, Pos. 170]

We also note that the COVID-19 crisis is likely to have increased the demand for AIV in 2022, as many respondents

believe that AIV consumption boosts their immune response. In principle, the pandemic could have affected hence the preference for own consumption of AIV and with it AIV marketing as well as the perception of solidarity. To address this potential confounding factor, we clearly related the questions in FGDs to AIV commercialization. In addition, we note that AIV commercialization started well before the pandemic (Hackfort et al., 2024).

Table 1. reports further characteristics of households. Crop diversity increased over time for households involved in selling AIV as well as households not involved, reaching a score of 10.9 for the former. We observe a significant difference between households selling and not selling AIV concerning crop diversity. This is due to the fact that non-selling households typically cultivate fewer AIV types, while those engaged in marketing tend to cultivate and sell a wider variety. The results also show that that farm households involved in AIV marketing are significantly more inclined to participate in AIV cooperatives, despite a decline in cooperative participation over time. Farm size decreased from 3.0 to 2.1 acre and 2.4 to 1.7 acre for households selling AIVs and not selling AIVs, respectively, as some households already started to inherit land to their children. Total non-food expenditures increased slightly for households selling AIV, while food expenditures increased for both groups. School expenditures decreased significantly as the ageing households have less children of school age in their homes.

4.2 Expenditure and subsistence effect

The results of the panel data models show that selling more AIV at the household level has a significant positive effect on logarithmized non-food expenditures of the last month,

Table 1 Summary statistics

	2016				2022			
	No AIV selling (N=112)		AIV selling (N=250)		No AIV selling (N=145)		AIV selling (N=217)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Household dietary diversity score (0-12)	9.759***	1.466	10.240	1.267	9.414*	1.686	9.737	1.503
Household consumption of AIV in last week (kg per cap)	0.495	0.498	0.569	0.436	0.506***	0.676	0.744	0.856
Total food expenditure of HH in past 1 month (PPP\$2015 per cap)	14.226*	11.589	12.083	10.183	22.347	21.737	20.381	18.190
Total non-food expenditure of HH in past 1 month (PPP\$2015 per cap)	350.700	369.988	338.028	274.397	334.226	307.591	358.538	396.274
Total school expenditure of HH in past 1 month (PPP\$2015 per cap)	160.330	272.382	172.385	215.615	113.064	183.882	128.105	319.806
Satisfaction with social equality in community (1-10)	6.134*	1.980	6.528	2.060	4.579	11.141	4.853	9.197
Satisfaction with community integration/supportive interaction (1-10)	6.607*	1.974	7.012	2.003	6.945	1.763	5.498	11.230
Age of HHH (years)	53.875	13.404	51.856	11.853	57.062	12.739	57.152	10.905
Female-headed household (=1)	0.196	0.399	0.168	0.375	0.276	0.448	0.212	0.410
HHH with primary education (=1)	0.375	0.486	0.432	0.496	0.434	0.497	0.447	0.498
HHH with secondary education and above (=1)	0.500	0.502	0.532	0.500	0.503	0.502	0.488	0.501
HHH migrated (=1)	0.063	0.243	0.064	0.245	0.103	0.306	0.078	0.269
Married HHH (=1)	0.893	0.311	0.884	0.321	0.731*	0.445	0.816	0.389
Change of HHH (=1)					0.145*	0.353	0.088	0.283
Wealth quintiles (1-5)	2.866	1.539	3.052	1.357	2.910	1.428	3.046	1.410
Farm size (acre)	2.402	3.645	3.040	8.127	1.680**	1.516	2.104	2.071
Crop diversity (count)	6.679***	3.228	7.868	2.220	8.103***	4.644	10.871	3.975
Owning livestock (=1)	1.000	0.000	0.988	0.109	0.890*	0.314	0.940	0.238
Access to saving account (=1)	0.402**	0.492	0.520	0.501	0.779	0.416	0.756	0.431
Member of AIV farmer group (=1)	0.348***	0.479	0.596	0.492	0.083***	0.276	0.194	0.396
Number of household members (count)	6.527**	2.305	7.116	2.226	6.138	2.385	6.323	2.456
Number of adult household members (count)	4.420	1.948	4.552	1.967	4.014	1.740	4.138	1.777
Employed HH members (=1)	0.455	0.500	0.412	0.493	0.379	0.487	0.378	0.486
Own business (=1)	0.241	0.430	0.216	0.412	0.255*	0.437	0.355	0.480
Share of crops gifted (0-100)	1.628	9.418	2.307	5.937	2.373	4.712	2.841	4.129
Share of AIVs gifted (0-100)	0.322**	2.576	1.894	7.276	2.441	7.140	1.653	4.798
Share of crops sold (0-100)	24.927	24.799	28.370	23.686	33.114	28.495	37.325	27.175
Share of AIVs sold (0-100)			57.023	19.763			55.107	26.218

HHH signifies household head. The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels testing the H0 of no difference (t-test) between households selling and not selling AIV in the respective year.

reported in 2015 purchasing power parity-adjusted U.S. dollars and per capita (Table 2, col. 1–2).³ In terms of effect size, we find that increasing the share of AIV sold by 10%

increases total non-food expenditures by 2.4% in our preferred FE specification, which controls for time-invariant unobserved heterogeneity. Some farmers also explicitly stated in the FGDs that selling more AIV improved living standards, even compared to selling other crops:

The standard of living has increased for most of households who practice serious AIVs production and selling. [Men from Nyacheeki Ward, Pos. 72]

³ A Hausman-test rejected the null hypothesis that the preferred model is random effects. We rely on our FE models for interpretation while reporting the random-effects (RE) model results as an additional robustness check.

Table 2 Effect of selling AIV on non-food expenditures

	(1)	(2)	(3)	(4)
	Non-food expenditure in last 1 month (log PPP\$2015 per cap)		School expenditure in last 1 month (log PPP\$2015 per cap)	
	RE Model	FE Model	RE Model	FE Model
Share of AIVs sold (0-100)	0.001* (0.001)	0.002** (0.001)	0.002 (0.001)	0.005** (0.002)
Share of other crops sold (0-100)	4.12e-04 (0.001)	0.001 (0.001)	-2.54e-04 (0.002)	-3.55e-04 (0.003)
Age of HHH (years)	-0.006** (0.003)	-0.001 (0.007)	0.007 (0.005)	0.024* (0.013)
Female-headed household (= 1)	0.111 (0.118)	0.302* (0.171)	0.292 (0.236)	0.515 (0.393)
HHH with primary education (= 1)	-0.098 (0.140)	-0.148 (0.187)	-0.438 (0.292)	-0.302 (0.464)
HHH with secondary education and above (= 1)	0.244* (0.145)	0.011 (0.214)	0.103 (0.298)	-0.292 (0.499)
HHH migrated (= 1)	-0.194* (0.100)	-0.286* (0.149)	0.085 (0.194)	0.303 (0.271)
Married HHH (= 1)	0.080 (0.116)	0.054 (0.126)	0.208 (0.220)	-0.058 (0.277)
Change of HHH (= 1)	-0.046 (0.124)	-0.238 (0.165)	-0.105 (0.201)	-0.288 (0.381)
Wealth quintiles (1–5)	0.141*** (0.022)	0.025 (0.036)	0.106*** (0.038)	-0.011 (0.073)
Farm size in ha (log)	0.080*** (0.031)	0.041 (0.051)	0.100** (0.050)	0.093 (0.076)
Crop diversity (count)	0.025*** (0.008)	0.021** (0.010)	0.039*** (0.015)	0.013 (0.023)
Owning livestock (= 1)	-0.275** (0.108)	-0.259 (0.165)	-0.748*** (0.200)	-0.864** (0.406)
Access to saving account (= 1)	0.191*** (0.061)	0.193** (0.082)	0.281** (0.119)	0.227 (0.168)
Member of AIV farmer group (= 1)	-0.012 (0.064)	0.023 (0.086)	-0.159 (0.117)	-0.239 (0.169)
Number of household members	-0.100*** (0.017)	-0.111*** (0.024)	-0.252*** (0.037)	-0.205*** (0.049)
Number of adult household members	0.064*** (0.021)	0.069** (0.027)	0.394*** (0.039)	0.305*** (0.056)
Employed HH members (= 1)	0.019 (0.054)	-0.023 (0.067)	-0.054 (0.098)	-0.155 (0.124)
Own business (= 1)	0.180*** (0.050)	0.180** (0.075)	0.053 (0.095)	0.063 (0.151)
Year 2022 (= 1)	-0.004 (0.010)	-0.006 (0.013)	-0.072*** (0.021)	-0.080*** (0.028)
Constant	14.258 (20.444)	17.894 (26.805)	150.515*** (43.033)	165.978*** (56.810)
Chi2	325.702		333.697	
F-Stat		3.612		4.429
Observations	724	724	593	593

Robust standard errors clustered at household level in parentheses. County dummies are included. In columns 3–4, we use only observations of households that had any education expenditures as proxy for having children in school age. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The returns from the sale of AIV is higher than the returns from the sale of exotic vegetables. [Men from Kisa West, Pos. 47]

This positive effect on total non-food expenditures appears to be partly driven by expenditures on education (Table 2, col. 3–4). In our preferred FE specification, we find that increasing the share of AIV sold by 10% significantly increases school spending by 4.5%. The finding that selling AIV increases expenditures on education is consistent with qualitative evidence that women use the income from AIV sales for expenditure items that are commonly considered to be more in line with women's preferences (Hackfort et al., 2024). The results also resonate with the multiple mentions in FGDs of the use of AIV revenues for school fees and other expenditures related to education:

It has even helped me to pay for my children's school fees. [Women from Marama, Pos. 36]

These results are confirmed in an additional robustness check using the area of AIV in hectares that a household dedicated to selling AIV instead of the share of AIV production sold (Table A2 in the Appendix). The results are also consistent with the few papers that exist on the effects of selling AIV, such as the cross-sectional analysis of Krause et al. (2019), who find a positive effect of selling more AIV on per capita household income using matching methods and an instrumental variable approach for identification. Regarding nutrition, we find no consistent effects, neither positive nor negative. We find no evidence of a significant subsistence effect, as weekly AIV consumption remains stable even with increasing selling of AIV (Table 3, col. 1–2). Certainly, selling more AIV should have reduced the quantity available for consumption if all else remained constant. However, production was not constant over the years for all households; rather, while the total AIV area of the sampled households decreased, households that sell a larger share of their AIV also increased their AIV area (Table A3 in the Appendix). This means that while the average share of farmers selling AIV reduced and also AIV acreage reduced within our sample, farmers that increased their AIV selling share also increased their AIV acreage. One farmer specifically emphasized the dual function of AIV.

We cultivate vegetables with two intentions. First, we cultivate for home consumption and secondly, we cultivate to get surplus for selling in order to get money. [Men from Kisa West, Pos. 46]

We also observed no income/expenditure effect of selling AIV on nutrition-related aspects, as the results suggest that the additional income does not translate into higher food expenditures (Table 3, col. 3–4). In general, food

expenditures are low compared to non-food expenditures. In 2022, households spent less than 10% of their total expenditures on food (Table 1.). We also found no significant effect on household dietary diversity scores (HDDS) (Table 3, col. 5–6). This is not surprising, as dietary diversity may have improved due to higher income from AIV sales, but as noted, households spend only a small fraction of their total expenditures on food (Table 1.). Dietary diversity could also have decreased due to lower production diversity, but this does not appear to be the case either. In general, the HDDS in the region is quite high, ranging from 9.76 to 10.24 for the different groups and survey rounds (maximum score is 12), with little room for improvement even if households would have increased their spending on food. Similar high scores were also found for smallholder farm households that produce vegetables and other horticultural crops in Kiambu county with a score of 11.4 (Sibhatu et al., 2015) and for farm households in Kisii and Nyamira county with a score of 9.72 (Muthini et al., 2020).⁴ In general, other studies also find little improvement in nutrition-related outcomes due to commercialization (Carletto et al., 2017; Chegere & Kauky, 2022; van Asselt & Useche, 2022). The effects of selling more AIV on nutrition outcomes, however, are mixed in Krause et al. (2019) showing a small increase in the HDDS using an instrumental variable approach but no consistent effects for the propensity score matching approach. The results are confirmed in an additional robustness check that used the area of AIV in hectares from a household dedicated to selling AIV instead of using the share of AIV production that was sold (Table A4 in the Appendix).⁵

4.3 Gender effect

We hypothesized that increasing demand and commercialization could provide an incentive for men to become involved in AIV cultivation, inducing them to retain some of the profits for themselves that would otherwise have been in the hands of women. First, we find indeed that men taking over the responsibility for AIV production is associated with increased sales of AIV, with significant effects for cowpea leaves and spider plants (Table A5 in the Appendix). The regressions reproduce the associations that Hackfort et al. (2024) found using data from 2015 to 2016. The increasing involvement of men could affect women's financial decision making and decrease food expenditures. Hackfort et al. (2024), however, also concludes from their analysis of FGDs

⁴ The HDDS are substantially lower for samples that also include non-farm households. Data from national representative survey from Ethiopia and Malawi show HDDS of 5.42 and 8.48, respectively.

⁵ We detect a weakly significant effect for HDDS in the fixed effects models; however, this finding is not substantiated by the results presented in Table 3.

Table 3 Effect of selling AIV on nutrition-related outcomes and food expenditures

	(1)	(2)	(3)	(4)	(5)	(6)
	Household consumption of AIV in past 1 week (kg per cap)		Food expenditures in past 1 week (log PPP\$2015 per cap)		Household Dietary Diversity Score (0–12)	
	RE Model	FE Model	RE Model	FE Model	RE Model	FE Model
Share of AIVs sold (0–100)	0.001* (0.001)	-1.65e-04 (0.001)	-0.001 (0.001)	-6.26e-05 (0.001)	0.002 (0.002)	0.003 (0.003)
Share of other crops sold (0–100)	-0.001 (0.001)	-0.001 (0.001)	9.18e-05 (0.001)	-0.001 (0.001)	-0.001 (0.002)	-0.005* (0.003)
Age of HHH (years)	0.005** (0.002)	0.007 (0.008)	-7.66e-05 (0.002)	0.001 (0.004)	-0.011** (0.006)	0.002 (0.014)
Female-headed household (= 1)	5.88e-05 (0.089)	0.211 (0.175)	0.128 (0.093)	0.160 (0.124)	-0.101 (0.213)	0.502 (0.405)
HHH with primary education (= 1)	-0.124 (0.105)	-0.133 (0.133)	-0.221** (0.100)	-0.177 (0.162)	-0.173 (0.254)	-0.308 (0.317)
HHH with secondary education/above (= 1)	-0.140 (0.097)	-0.240* (0.140)	-0.177* (0.102)	-0.048 (0.169)	-0.219 (0.259)	-0.018 (0.367)
HHH migrated (= 1)	0.060 (0.153)	0.203 (0.156)	-0.190* (0.102)	-0.222* (0.118)	-0.030 (0.204)	0.002 (0.274)
Married HHH (= 1)	0.027 (0.084)	0.007 (0.108)	0.158* (0.094)	0.257** (0.117)	-0.132 (0.212)	0.172 (0.282)
Change of HHH (= 1)	-0.187* (0.095)	-0.309** (0.136)	0.001 (0.093)	0.017 (0.127)	-0.043 (0.260)	-0.067 (0.379)
Wealth quintiles (1–5)	0.045** (0.020)	0.070* (0.037)	0.112*** (0.018)	0.062** (0.030)	0.226*** (0.044)	0.067 (0.078)
Farm size in ha (log)	0.025 (0.033)	0.012 (0.047)	-0.028 (0.029)	-0.020 (0.033)	0.029 (0.065)	0.063 (0.109)
Crop diversity (count)	0.024*** (0.008)	0.020* (0.010)	0.006 (0.006)	0.006 (0.007)	0.070*** (0.015)	0.043** (0.019)
Owning livestock (= 1)	-0.013 (0.103)	-0.200* (0.109)	-0.156 (0.125)	-0.041 (0.136)	0.487* (0.276)	0.499 (0.354)
Access to saving account (= 1)	0.055 (0.042)	0.081 (0.068)	0.138*** (0.051)	0.158** (0.068)	0.298** (0.120)	0.464*** (0.171)
Member of AIV farmer group (= 1)	0.086 (0.059)	0.096 (0.080)	0.190*** (0.053)	0.265*** (0.063)	0.065 (0.115)	0.150 (0.160)
Number of household members	-0.067*** (0.015)	-0.060*** (0.020)	-0.074*** (0.018)	-0.032 (0.022)	0.028 (0.035)	0.096* (0.053)
Number of adult household members	-0.009 (0.015)	-0.031 (0.026)	-0.017 (0.022)	-0.046* (0.024)	-0.022 (0.046)	-0.031 (0.057)
Employed HH members (= 1)	-0.036 (0.053)	-0.007 (0.062)	-0.073 (0.047)	-0.089 (0.058)	0.053 (0.112)	-0.108 (0.156)
Own business (= 1)	-0.083 (0.052)	-0.103* (0.060)	0.066 (0.048)	-0.019 (0.064)	0.133 (0.107)	0.123 (0.158)
Year 2022	0.007 (0.009)	0.001 (0.013)	0.005 (0.009)	0.019* (0.011)	-0.098*** (0.021)	-0.087*** (0.029)
Constant	-12.863 (19.082)	-1.853 (25.343)	-9.075 (17.995)	-36.834* (21.326)	206.13*** (41.387)	182.92*** (57.715)
Chi2	72.025		145.732		193.491	
F-Stat		2.628		3.919		3.694
Observations	724	724	712	712	724	724

Robust standard errors clustered at household level in parentheses. County dummies are included. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

that women's decision-making power, which includes control over financial resources, is not adversely affected by men becoming more involved in AIV cultivation.

Whenever I need money for my own needs, it is not a must that I ask the husband for the money. I can just go in the farm and harvest some AIVs and sell to get my own money. [Women from Getenga Ward, Pos. 11]

The authors show that women retained control over AIV marketing and, hence, associated profits. The analysis aligns with our results on household expenditures, which indicate an insignificant effect on food expenditures, suggesting that there are no major unilateral changes in gender relations affecting food expenditures. Instead, we find that the additional income from AIV selling is used for non-food expenditure purposes (Table 2). We lack data to determine if women have less time for cooking and preparing food in general due to AIV marketing, which is a time-consuming activity. Yet, women in general report an increased labour burden in the FGDs due to commercialization (Musotsi et al., 2018; Hackfort et al., 2024).

4.4 Resource sharing and solidarity effect

In this section, we compile evidence on the effects of AIV commercialization on resource sharing and intra-community solidarity using our quantitative and qualitative data. Table 1. shows that the share of AIV and of other crops that was given away to other household for free was already marginal in 2016 with shares about 1 to 2%. However, the results in Table 4 (col. 1–2) indicate that households that market their AIV production more have further reduced not only the share of AIV production for their own use, but also the share of AIV production given away to other households. Households that completely market their production reduce AIV gifting by 2% in our preferred FE specification (Table 4, col. 2). This link between market orientation and resource sharing is also reflected in production patterns of all other crops (Table 4, col. 3–4). However, the quantitative data are insufficient to account for changes over longer time periods, as we have previously argued that selling AIV on markets began well before 2016. We therefore draw on our qualitative data from the FGD interviews to describe longer-term changes in resource sharing. There are several mentions in the FGDs that resource sharing has decreased. Farmers report that prior to commercialization, AIVs were shared for free. Farmers also explicitly link this to the increased need to pay bills.

It has reduced relations. Traditionally, you could hear people tell their neighbours to come and pick some vegetables, that's what women used to do; right now, they cannot do that because it translates to money and

this has reduced relations because everyone is now business minded and when they look at the AIVs they see money and not friendship. [Men from Marama West, Pos. 131]

People have become disunited because everyone wants money. Farming has been turned into agribusiness. There are bills to be paid like school fees, buying of fertilizer among others. Traditionally, AIV were shared. Nowadays we don't share. [Men from Masimab, Pos. 76]

It is also important to note that before commercialization, people not only shared the AIV for free, but also worked on the farms without receiving any compensation.

Before commercialization neighbours used to help each other when preparing the farms for free. Post commercialization of AIVs has led to people not helping each other. Now, people pay just to be helped to prepare the farms. [Women from Getenga, Pos. 19]

The FGDs clearly indicate that resource sharing has decreased with AIV commercialization, which is perceived by some farmers as a loss of community solidarity. In theory, this could also have led to a reduction in food security if households that rely on receiving AIV as a gift slowly lose access and informal sharing arrangements, which are important safety nets for the poorest households, deteriorate. On average, however, farmers do not rely heavily on AIV gifting for their consumption (Fig. 1). Using quantitative data, we find a weak positive and significant effect on respondents' satisfaction with social equality in their community and no significant effect for social integration and supportive interaction with neighbours based on the share of AIV gifted (Table A6 in the Appendix). While we have to acknowledge that these perceptions might be different for poorer farmers and the models also suffer from poor model fit, we also explain the ambiguous results with the heterogeneous and contrasting effects that farmers reported during the FGDs in terms of their perception of community solidarity. While quotes from the resource sharing section suggest that some farmers perceive a loss of solidarity, not all farmers see commercialization as detrimental to social relations. For example, knowledge sharing became more important with AIV commercialization which in turn strengthened social relations.

It has brought us together in the sharing of ideas. Someone will advise you that if you do this, you will get more returns. [Women from Khalaba, Pos. 114]

It has brought us together in that like my father here has planted spider plant and it is doing well, so he will advise me on what to do so that I can also benefit by producing; and if he gets a customer and his produce is not enough, he will combine with mine and I will

Table 4 Effect of selling AIV on informal sharing

	(1)	(2)	(3)	(4)
	Share of AIV production gifted (0-100)		Share of production of all crops gifted (0-100)	
	RE Model	FE Model	RE Model	FE Model
Share of AIVs sold (0-100)	-0.021*** (0.006)	-0.020* (0.010)	0.009 (0.007)	0.012 (0.009)
Share of crops sold (0-100)	0.001 (0.009)	0.007 (0.013)	-0.022*** (0.008)	-0.050** (0.021)
Age of HHH (years)	-0.002 (0.030)	0.039 (0.044)	-0.021 (0.029)	-0.041 (0.038)
Female-headed household (= 1)	-1.437** (0.605)	2.416 (2.061)	-0.024 (0.596)	0.984 (1.244)
HHH with primary education (= 1)	-0.855 (1.074)	-1.902 (1.940)	-1.116 (0.882)	0.292 (1.239)
HHH with secondary education and above (= 1)	-0.554 (1.102)	0.391 (2.276)	-1.073 (0.929)	-0.758 (1.509)
HHH migrated (= 1)	0.136 (0.833)	0.213 (1.281)	-0.533 (0.612)	-0.681 (0.989)
Married HHH (= 1)	-1.270 (0.860)	-1.746 (1.128)	-0.191 (0.627)	-0.474 (0.947)
Change of HHH (= 1)	-0.650 (0.843)	-3.313* (1.899)	-0.990 (0.700)	-0.338 (0.954)
Wealth quintiles (1–5)	-0.064 (0.183)	-0.147 (0.302)	0.329* (0.173)	0.160 (0.426)
Farm size in ha (log)	0.342 (0.247)	0.211 (0.365)	-0.055 (0.189)	-0.294 (0.365)
Crop diversity (count)	0.082* (0.042)	-0.028 (0.106)	-0.070 (0.062)	-0.138 (0.093)
Owning livestock (= 1)	-0.943 (1.701)	1.208 (2.233)	0.056 (0.914)	0.809 (1.304)
Access to saving account (= 1)	-0.316 (0.558)	-0.015 (0.660)	0.610 (0.593)	0.137 (0.792)
Member of AIV farmer group (= 1)	-0.720 (0.443)	-0.906 (0.660)	0.034 (0.619)	0.996 (0.887)
Number of household members	-0.261** (0.121)	-0.112 (0.185)	-0.217 (0.198)	0.123 (0.216)
Number of adult household members	0.181 (0.213)	-0.175 (0.282)	-0.035 (0.137)	-0.225 (0.206)
Employed HH members (= 1)	-0.236 (0.490)	-0.349 (0.587)	0.880* (0.493)	-0.152 (0.660)
Own business (= 1)	0.190 (0.521)	1.434** (0.664)	0.133 (0.516)	-0.399 (0.984)
Year 2022 (= 1)	-0.003 (0.108)	-0.023 (0.094)	0.143* (0.086)	0.300*** (0.092)
Constant	11.035 (218.910)	49.904 (189.898)	-283.956 (174.191)	-600.349*** (186.843)
Chi2	30.796		59.585	
F-Stat		1.525		2.166
Observations	724	724	724	724

Robust standard errors clustered at household level in parentheses. County dummies are included. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

have made business. The buyers also get to share contacts and so you get to meet so many people and have a wider network. [Women from Khalaba, Pos. 116]
... commercialization of AIVs has brought people in the village together. This is because you can get advice and learn from each other on how to get the best results from your farm. [Women from Kisa West, Pos. 58].

In addition, households formed cooperatives, some of which function as new platforms for social interaction and solidarity. Women in particular are involved in small banking and savings cooperatives to support each other and share resources.

It has also brought about women empowerment and development. If we are in a group, we decide on how to spend the savings for the benefit of every member. We can decide to buy household items until every member has them. [Women from Nyacheki, Pos. 90]

Forming groups also helps them to build relationships along the AIV value chain to access markets beyond the local village by establishing a system to distribute AIV to greater distances, such as the capital, benefiting from a division of tasks and responsibilities among them. This has created new patterns of interaction that shape farmers perception of solidarity.

If we had a cooperative for AIVs farmers such that when we produce, we have somewhere to collectively take our produce and the cooperative looks for the market. In such a case, no one will go at a loss as an individual because you are taking your AIVs somewhere you are guaranteed the payment and they also have ready market; even the transporters know they will get their pay and those that have been trusted will deliver the product where is supposed to be delivered. [Women from Marama Central, Pos. 139]

Another one I have seen is that there are women farmers who collect vegetables from us and take them to Nairobi city. I have seen that they are so united such that there is one of them that remains in the city and those who remain here to collect the vegetables and put them in the vehicle for transportation. [Women from Marama Central, Pos. 82]

In addition to the new relationships and platforms, some farmers perceive these new relationships as fairer than before commercialization. For example, they indicate that commercialization has reduced “forced solidarity” in communities and free-riding by households. It is unlikely that these households perceive the commercialization of AIV as affecting solidarity within the village.

People had the habit of borrowing. But they are aware that they have to cultivate or buy. So the laziness has decreased. [Men from Maraa central, Pos. 17]

I would say that farming indigenous vegetables has reduced idleness because if I go to visit my friend and find her busy on her farm, how will I stand there and gossip with her? I will go my way and find something to occupy myself with and maybe next time I will come to seek advice from her on how to produce the vegetables and then go to put her teaching into practice on my own farm. [Women from Marama Central, Pos. 77]

Adding to his point, it has brought changes in relations in that the lazy ones hate the hardworking ones; but for the wise, they have gained knowledge from others and used it for their own development. So, there are areas that the relations have become better because they did not take for free and also on focusing on the development and copying that has brought even more growth. [Men from Getenga, Pos. 115]

This analysis shows that not all farmers perceived the effects of AIV commercialization on resource sharing and solidarity as negative, underscoring that the commercialization of AIV has also created new relationships that are now perceived as fairer and more equitable by some farmers.

However, some farmers see trade-offs between income and solidarity and also mention this trade-off explicitly.

Despite the positive business aspects, there is not unity among villagers. It's fifty-fifty. [Men from Magenche, Pos. 15]

Overall, our analysis suggests that, on average, farmers are no less satisfied with community solidarity after AIV were commercialized and, for example, cooperatives partly replaced the functions of the informal sharing arrangements. However, it is still possible that poorer households without access to land and other inputs for growing AIV lost access to highly nutritious vegetables because of the increasing importance of market-oriented farming in the region. Further research is needed to understand the impacts on these households.

5 Conclusion

Our study builds upon qualitative FGDs and panel data reaching from 2016 to 2022 to analyse the trade-offs between smallholders' living standard and nutrition-related outcomes and resource sharing following the shift from subsistence to more market-oriented farming of AIV in Kenya. Using FE models, the results of the study suggest that selling AIV has a positive effect on income as non-food expenditures increased significantly, particularly for education. The FGDs also reflect farmers perception that selling AIVs is highly

profitable. There is no negative effect of selling AIV on farm households' nutritional intake, as weekly AIV consumption and dietary diversity remains stable even with increasing market participation as farmers that sell more AIV increase their AIV acreage at the same time. This is reassuring as the commercialization of an important and highly nutritious subsistence crop could have had negative effects on dietary diversity but close to all farm household continue to consume AIV on a weekly basis regardless of their market participation. Yet, dietary diversity also does not improve as we observed no significant impact on food expenditure.

Our panel data models show that increasing AIV selling did decrease the share of gifted AIV production over time, and some farmers relate this to decreased community solidarity. Using panel data models, we find however no consistent and robust evidence that solidarity indicators changed over time with AIV commercialization. We relate this to our finding from the FGDs that there is no unidirectional effect of commercialization on solidarity, but rather multiple and sometimes opposing mechanisms at work. While we consistently find evidence in the FGDs that perceived solidarity has decreased due to less frequent non-monetary exchanges of AIV, some farmers emphasize that they perceived this traditional form of solidarity to be partially forced. Other forms of social interaction, such as cooperatives and more intensive knowledge sharing, also emerged in the wake of commercialization. Although, not all cooperatives remained operational over an extended period, with one major cooperative having dissolved in Kakamega between both survey rounds, many farmers suggest that these new forms of cooperation have increased community solidarity. Nonetheless, it is possible that less affluent households lacking access to land and essential resources for cultivating AIV may have encountered difficulties in obtaining highly nutritious vegetables due to decreased informal sharing in the wake AIV commercialization. Overall, reported increases in expenditures provide a strong incentive for continued growth in the AIV sector, and the null effect on nutrition and heterogeneous concerns about the loss of community solidarity are unlikely to halt this trend.

The study involves some caveats. First, our identification strategy does not allow us to control for time-variant confounding variables. Second, while our panel data spans over six years, this time frame is likely to be too short to completely track the changes in community solidarity and resource sharing over time. While we try to address this shortcoming by using FGDs interviews, the regression analysis focusing on solidarity and resource sharing cannot completely capture long-term changes. Second, we only focus on the effects of AIV commercialization on a specific part of the population but do not capture the effects on the rural households that are not engaged in the AIV sector nor on the urban population. Overall, more research is needed

to understand the effect of AIV commercialization, in particular in the light of growing funding and attention for agroecological approaches. AIV cultivation is regarded as part of the agroecological approach to improve food security due to aspects such as crop diversity, co-creation of knowledge, little reliance on external resources, enhanced resilience of communities and ecosystems, in particular in respect to climate change, and supporting healthy, diversified and culturally appropriate diets (Bezner Kerr et al., 2021; Madssen et al., 2021; von Braun et al., 2023). More research is also needed to understand the effect of market access on the social fabric of rural communities. The recent global crises did not only reignite the debate on food security in SSA but also point to the important role of societal traits in dealing with external shocks (Bargain & Aminjonov, 2020; Razavi et al., 2020; Riley, 2018; Thomas et al., 2022). Albeit the potential growth of the AIV sector, concerns about the loss of informal sharing arrangements and community solidarity may need to be addressed to ensure sustainable development. The study overall highlights the complex trade-offs within the shift from subsistence to a more market-oriented agricultural system in SSA.

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Declarations

Conflict of interest The authors declare no conflict of interest.

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