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Debunking the One-size-fits-all Approach: Synergistic and Trade-off Effects of Collective Action on Household Food Security Among the Smallholder Farmers in Central Kenya

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Collective action is important in ameliorating the negative externalities in agriculture to promote household food security (HFS). This study explored the effects of efficiency and livelihood collective action initiatives (CAIs) on HFS along the pathways of production and income. The efficiency CAIs pursue efficiency-enhancing collective activities including input sourcing and output marketing. The livelihood CAIs engage in household livelihood and resilience enhancing collective activities such as provision of credit and informal insurance, pooling savings and acquisition of assets. A multinomial endogenous treatment effects (METE) model and an ordered probit model were employed on cross-sectional data drawn from 532 households from Murang'a County in central Kenya. The results revealed significant differences in HFS between the efficiency and livelihood CAIs. The differences were accounted for by the variations in household and organizational characteristics that determine the capacity to leverage HFS benefits along the pathways of production and income. Both efficiency and livelihood CAIs showed a positive significant effect on HFS through production. The results further showed that income positively influenced HFS among the livelihood members contrary to efficiency CAIs that showed negative HFS effects. The HFS across the combined pathways of income and production was lower for the efficiency CAIs than the livelihood CAIs. This was mainly due to the trade-off income effects exhibited by the former and the synergies accrued from income and production on the latter. The findings suggest that the overall performance of both efficiency and livelihood CAIs in leveraging HFS from joint income and production remains tentative. Therefore, a one-size-fits-all collective action promotional policy and program design approaches for improved HFS outcomes are inadequate. The study suggests a portfolio of context-specific collective action policies and interventions that match the differences between the efficiency and livelihood CAIs and their links to HFS. The policies would confer potential synergies, spillover effects and complementarities in strengthening the synergies while mitigating the trade-offs along the income and production pathways between the efficiency and livelihood CAIs. There is a need to enhance access to information, extension and advisory services and ICT among the members of the livelihood CAIs to improve production. It is important to incentivize the non-farm livelihood-enhancing economic activities among the livelihood members to fill the household food gaps arising from low production. It is also important to establish collective action funds and micro-credit schemes with affordable interest rates. This would help to tap the opportunities for credit sourcing and pooling savings among the livelihood members while promoting collective input sourcing and output marketing among the efficiency CAIs.

Keywords: Collective action, food security, production, income, multinomial endogenous treatment effect model, Kenya.

INTRODUCTION

The growth in population coupled with urbanization, rising incomes, and evolving trends in dietary consumption patterns, is expected to increase the demand for food worldwide (Food and Agricultural Organization, FAO, 2023). Already, the number of people experiencing food insecurity and multiple forms of malnutrition has been on an upward trajectory in the past three years from 8 per cent in 2019 to almost 10.5 per cent in 2021(FAO, 2023) The Sub-Saharan Africa (SSA) region in particular accounts for the highest prevalence rates of up to 23.4 per cent of the 823 world's undernourished

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population (FAO, 2023). In Kenya specifically, the number of people facing hunger is also high, representing about 26.9 per cent of its total population (Kenya National Bureau of Statistics, KNBS, 2023). In the country, about 33 per cent of the population subsists on less than the required daily capita calorific threshold of the recommended 2250 kilocalories, a trend that has been on the upturn by about 8.8 per cent between the years 2014 to 2022 (KNBS, 2023). The prevalence of food insecurity in SSA disproportionately affects rural smallholder households despite contributing to almost 75 per cent of the food consumed in the region as food producers, wage workers, processors and traders (KNBS, 2023).

The persistence and vulnerability of food insecurity among smallholder farmers has been attributed to pervasive market failures including asymmetric information and high transaction costs (Njuguna *et al*., 2022). The confluence effects of poverty, low public intervention and geographical dispersion exacerbate the effects of transaction costs in accessing productive resources such as input and output markets, extension and advisory services, finance, credit and agricultural technologies (Njuguna *et al*., 2022). These constraints limit the capacities of the smallholders to improve farm productivity and generate incomes in safeguarding food security for their households (Valujeva *et al*., 2023). In this context, the national and transnational developmental discourses have been growingly promoting collective action as a survival strategy that can address the food security challenges through production, income and gender impact pathways (Nosratabadi *et al*., 2020). Despite this, the empirical basis exploring the linkages between collective action and household food security (HFS) and its associated agricultural-nutritional pathways has received less attention to date. Collective action refers to a set of voluntary initiatives and actions undertaken by a group of individuals to achieve some shared and mutual welfare-enhancing activities at social and economic levels (Lupi *et al*., 2021). Like the rest of SSA, some of the common examples of collective action initiatives (CAIs) among the smallholder farmers in SSA include producer and marketing groups, savings and credit groups, community-based organizations and water and forest user associations (Cramer *et al*., 2016).

The novelty of collective action underpins its potential in forming an interface between the farmers and their socio-economic environments in enhancing efficiency and effectiveness in production and marketing processes (Kwizerimana *et al*., 2023; Zou and Wang, 2022). This is through ameliorating the transaction costs in accessing productive resources, farm inputs, technologies and output markets (Zou and Wang, 2022). Collective action also provides rich income-generating opportunities for non-agricultural diversification activities such as pooling of savings and acquisition of assets that can improve agricultural production by mitigating the farmers' liquidity constraints and smoothing household incomes (Hintz and Pretzsch, 2023). In addition, non-agricultural activities provide informal insurance that cushions the households against the potential idiosyncratic and covariate shocks (Malual and Mazur, 2022). The standard proposition in the literature holds that participation in collective action translates to HFS through the agricultural-nutritional pathways of farm production and household income (Nosratabadi *et al*., 2020; Shumeta and D'Haese, 2018).

However, the extant studies reveal mixed evidence on the effect of collective action on HFS along the two pathways. For instance, collective action provides rich opportunities to improve HFS through farm productivity and incomes through the synergistic effects of intensive production and ease access to farm inputs and renumerated markets that offer better market prices leading to farm profitability (Linderhof *et al*., 2019). However, on one hand, the market-oriented or efficiency CAIs require high capital outlay and as such they favour the older, wealthier and large-scale male farmers and thus exclude the resource-constrained farmers from participating therein (Mwambi *et al*., 2020). Conversely, larger farm sizes may put more demands on the households' labour which would increase the farmers' opportunity costs of time for participating in group meetings, agricultural training and collective market days (Fischer and Qaim, 2012a; Woldu *et al*., 2018). In addition, increased focus on market-oriented production could also lead to the diversion of resources to cash crop production at the expense of for-home consumption production (Kirimi *et al*., 2013; Shumeta and D'Haese, 2018). Since most of the food consumed in smallholder households comes from own production, market-oriented production is likely to increase dependence on food markets which could expose the farmers to price volatility (Kirimi *et al*., 2013).

Conversely, due to poverty, the income derived from collective activities including marketing, savings and credit is likely to be diverted from HFS needs to essential non-food items including education, health, agricultural inputs, home improvement and asset acquisition (Linderhof *et al*., 2019). Additionally, a study done by Sraboni and Quisumbing (2018) shows that the collectively generated incomes may not translate to HFS due to the social norms limiting women's control of household incomes and expenditures. This can pose adverse effects on HFS since women play integral roles in food production, domestic work and caregiving that influence the nutritional outcomes of their households (Njuki *et al*., 2021; Quisumbing *et al*., 2021). The resource-constrained smallholder farmers notably women are risk averse and this implies that they are less likely to take risks associated with collective marketing such as defaulting on sale contractual agreements and rejection of the farm produce due to failure to meet the designated standards (Gyau *et al*., 2016). Therefore, the resource-constrained farmers and women prioritise livelihood-enhancing, household-risk reduction and food self-

sufficiency options by engaging in CAIs that focus on accumulating household assets, pooling savings, sourcing credit and providing informal insurance (Dhal *et al*., 2020). However, the financial obligations in contributing to the savings and informal insurance kit coupled with the inability to repay the credit may leave the farmers impoverished and food insecure (Ganle *et al*., 2015).

The inconsistent findings imply that the effects of collective action on HFS depend on the socio-economic characteristics of the households and the organizational attributes of the CAIs. This is because farmers are heterogeneous entities in their demographic and socio-economic conditions, resource endowment and utilization and social networking patterns (Cramer *et al*., 2016; Min-Han Tsai and Yir-Hueih, 2022). Therefore, farmers employ heterogenous transaction-cost-reducing strategies in mobilizing across the CAIs depending on their abilities and needs (Min-Han Tsai and Yir-Hueih, 2022). The heterogeneities imply that the farmers adopt different collective coping mechanisms for agricultural risks and shocks to improve production and the generation of incomes (Zou and Wang, 2022). This leads to win-win, win-loss or loss situations on the nature and extent of HFS leveraged and their associated nutritional pathways. Despite this, the context-specificity of these concepts has remained obscure in literature yet they pose implications on the choice of the analytical framework, interpretation and generalization of the findings.

The extant research stream typically employs pooled regression analyses with the collective action dummy indicating whether a farmer participates or not in regressing the effects of collective action on HFS. This approach makes it difficult to disentangle how different CAIs would respond and benefit from the households' investments and promotional policies and the subsequent HFS leveraged vis-à-vis the households' investment strategies and the promotional policies these CAIs might need to optimise the HFS benefits (Dhal *et al*., 2020). As a result, this approach dissipates the collective action policies and program design into a 'one-size-fits-all' approach that may pose a threat to the development of the CAIs in promoting HFS (Republic of Kenya, 2019). This study focusses on the producer and marketing groups, savings and credit groups, community-based organizations and water and forest user associations. These CAIs are classified according to their economic functions into market-oriented or efficiency and community-oriented or livelihood CAIs. The two forms of CAIs are distinct in their gender composition, nature of activities, level of social capital and level of social networking (see the next sub-section).

The study employs the rich household survey data from the smallholder farmers from Murang'a County in the central region of Kenya to explore the effects of participation in efficiency and livelihood CAIs on HFS. Murang'a County presents a suitable representative case study because it accounts for up to 65 per cent of the aggregate membership of the agricultural CAIs in Kenya (KNBS, 2023). In particular, like the rest of the country, the efficiency and livelihood CAIs are prominent in the county. However, to the best of our knowledge, no study has explored the effects of the two categories of CAIs on HFS. This study contributes to the discourse of collective action and HFS by exploring: 1) How participation in efficiency CAIs affects HFS along the nutritional pathways of production and income; 2) How the HFS are differentially influenced by the household and organizational characteristics of the livelihood and efficiency CAIs; 3) How HFS outcomes are differentially influenced by the nutritional pathways of income and production across the efficiency and livelihood CAIs. The study employs a multinomial endogenous treatment effects model (METE) to explore and disaggregate how participation in efficiency and livelihood CAIs influence HFS along the nutritional pathways of production and income. The METE model controls for the endogeneity problem that may arise due to reverse causality between collective action participation and HFS outcomes, which although evident, has not been addressed in most empirical studies. The study also employs an ordered probit model to provide a real account of the differential effect of interactions between the household socio-economic attributes and organizational characteristics of the two forms of CAIs and HFS.

Understanding the differences and causes of differences of HFS across the efficiency and livelihood CAIs has implications, especially on interventions aimed at improving the HFS status of the smallholder households in particular. From a policy perspective, the insights of the study would inform the design and implementation of more context-specific and nutrition-sensitive collective action program design and promotional policies. The next sub-sections present the descriptions of efficiency and livelihood CAIs, the nexus between collective action and HFS and the conceptual framework. Section two presents materials and methods describing the study area, data and empirical strategies. Section three discusses the results and section four draws the conclusion and the policy implications of the study.

The efficiency and livelihood collective action initiatives: The efficiency CAIs pursue efficiency-enhancing activities in reducing transaction costs in production and marketing processes including collective purchasing of farm inputs, collective bulking and marketing of farm outputs. They are largely dominated by men owning larger farm sizes and they practise market-oriented production. The efficiency CAIs are highly formalized and they operate as primary solo entities or as second-tier amalgamations in the form of cooperatives or unions. They are characterised by high bridging social capital in networking with the government, non-government organizations and agribusiness companies to receive extension and advisory services as well as technical training. The majority of the smallholder households do not prefer

efficiency CAIs because: they require large amounts of capital for investing in membership fees, share contributions and meeting production standards; they are prone to risks such as rejection of farm produce due to failure to meet the stipulated standards; defaulting of the contractual agreements by the potential buyers; and delay in disbursement of the payment from the collective sales.

The livelihood CAIs engage in food self-sufficiency and livelihood-enhancing activities in reciprocal and collective asset acquisition, pooling of savings, provision of informal insurance and sourcing of credit either internally or with bank linkages. The livelihood CAIs constitute the majority of the membership largely dominated by women, owning small land sizes and practicing subsistence farming. The livelihood CAIs operate informally due to the inability of the farmers to meet the membership fees and annual subscriptions. Contrary to the efficiency CAIs, they are characterised by high levels of bonding social capital. This is because they operate as single entities, consisting of members with kinship ties or from the neighbourhoods and largely grounded on customary principles and ideas of promoting the members' well-being.

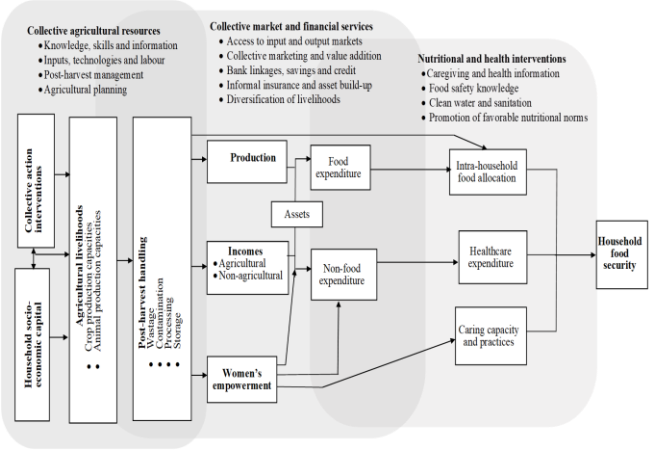
The nexus between collective action and household food security: The (FAO, 2023) states that "food security exists when all people, at all times, have economic, physical and social access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for a healthy life". In this regard, collective action provides multiple and synergistic functions that can promote HFS along the three interlinked pathways of production, income and women empowerment as shown in Figure 1. However, this study is limited to the two pathways of production and income. Literature reveals inconsistencies in the effects of collective action on HFS. This is because the farmers mobilize depending on their needs, priorities and abilities, and as a consequence, they collectively adopt divergent transaction-cost-reducing mechanisms in promoting agricultural production and generation of incomes (Min-Han Tsai and Yir-Hueih, 2022).

For instance, collective action influences own farm production through the effects of input as a result of a reduction in the transaction costs per unit in accessing farm inputs including seeds, fertilizers and extension and advisory services either through government schemes, output market providers and certified input providers (Gyau *et al*., 2016). Agricultural production influences HFS directly when households consume what they produce in form of type, seasonality and quantity of food (Lutomia *et al*., 2019). Production can also influence HFS indirectly through its multiplier effects on incomes when agricultural produce can be sold to generate incomes which can be allocated to purchasing nutritionally dense foods as well as the availability of diverse foods in the local markets and the food prices (Harris-Fry *et al*., 2017; Ragasa *et al*., 2019).

Collective action can also improve production through the acquisition of production and marketing skills, information, knowledge and experiences arising from the synergistic and spill-over effects of peer social learning, grassroots innovation, vocational training and extension and advisory services (Larsen and Lilleør, 2014; Nosratabadi *et al*., 2020). Additionally, the provision of collective training on post-harvest handling practices can increase the farmers' opportunities to improve HFS through minimising the losses associated with a decrease in food supplies, diminished market value, food safety and nutritional content of food and non-food crops (Mutungi *et al*., 2023). This could enhance own-farm diversification in meeting own consumption needs and increasing market surplus (Linderhof *et al*., 2019). However, diverse farming depends on the availability of the household's off-farm income, larger land sizes and market participation opportunities (Waha *et al*., 2018). Furthermore, women farmers in particular face high opportunity costs for attending such trainings that are important in improving post-harvest management, production and marketing skills (Nakazi *et al*., 2017). Collaboration of the farmers can influence production through the supply of reciprocal labour among the members (Andersson and Gabrielsson, 2012). This is particularly important with the increasing phase of rural-urban migration that has created labour shortages in rural farming (Kehinde *et al*., 2021).

Collective action improves the commercialization of agricultural outputs to improve HFS through production arising from synergistic effects of competitiveness and gains in income (Kirimi *et al*., 2013). However, evidence shows substantial improvements in collective commercialization among the older collective marketing groups that are well endowed with land belonging to groups characterised with inclusivity in decision-making and high levels of bridging and bonding social capital (Fischer and Qaim, 2012a; Niles *et al*., 2021; Sseguya *et al*., 2018). Otherwise, the newly formed CAIs can be constrained by low mutual trust and uncertainties over reciprocity incentives. On the contrary, other studies found negative associations between bridging social capital and HFS (Koster *et al*., 2021). Among the households, Kihiu and Amuakwa-Mensah (2021) assert that larger effects of HFS can be realized through commercialization when both men and women in the household are guaranteed equal access to the markets. In addition, substantial effects of HFS are accrued among well-educated male farmers who own larger farm sizes and are knowledgeable on production (Bernard and Taffesse, 2012).

An increase in income through product commercialization could increase the purchasing power and smooth consumption of more nutritious and diversified diets by increasing the demand for fruits and animal products to replace the pulses and cereals, which make up the bulk of household diets, particularly in Kenya (Fongar *et al*., 2019).



Source: Authors' conceptualisation

Figure 1. Linkages between collective action, agriculture and household food

In addition, income eases the farmers' budgetary constraints by increasing expenditure on non-food items including education, assets, farm inputs and healthcare (Ragasa *et al*., 2019; Harris-Fry *et al*., 2017; Kihiu and Amuakwa-Mensah, 2021). Incomes can also enhance HFS through the multiplier effects of increased production, demand for labour and farm inputs and creation of local employment (Wegi *et al*., 2023). Conversely, households with low-income resources and budgetary constraints face trade-offs between spending on food items and non-food items such as education and healthcare (Kaiser *et al*., 2020). Commercialization of agriculture through collective marketing is perceived as an avenue of generating more household income due to its comparative advantages over subsistence farming, however, it is also seen as a shift from subsistence to cash crop farming (Linderhof *et al*., 2019). This can lead to a decline in diversification and a loss in food self-sufficiency at the farm level hence increasing dependence on local markets (Kirimi *et al*., 2013). Areas where markets are not well integrated and characterised by poor infrastructure and linkages can pose risks to household incomes such as price hikes (Poole, 2017) For instance, a study by Shumeta and D'Haese (2018) shows that collective marketing does not translate to HFS through production because farmers tend to divert their resources from food self-sufficiency production to cash-crop-oriented production. Households with access to collective action credit and savings can easily mitigate such risks, otherwise, subsistence farming serves as a form of insurance against the costs and risks of the markets (Kirimi *et al*., 2013).

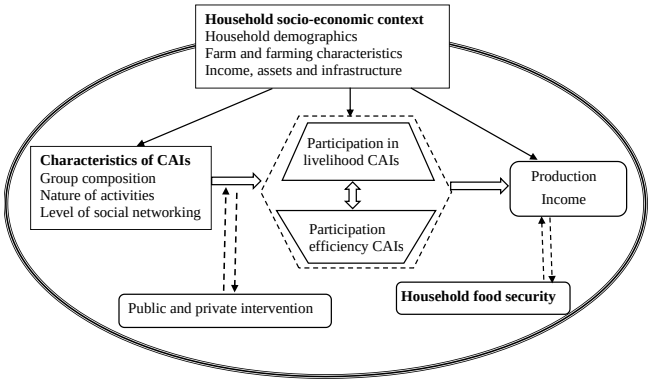
Formalization of the CAIs is also an important factor in determining HFS. Evidence reveals that the formalized CAIs that are registered as business entities are well-socially networked and therefore stand a high chance of receiving economic and technical support from public and private partnerships Fischer and Qaim (2012a). However, the resource-constrained households may opt for informal collective arrangements due to the inability to meet registration fees and annual membership renewal fees. Group composition also plays a critical role wherein mixed-gender CAIs contribute to diverse leadership skills, knowledge and organizational capacities that can enhance the HFS benefits leveraged and overall organizational performance (Dohmwirth and Hanisch, 2018). Conversely, the social norms limiting women's speaking in public imply that the mixed-gender CAIs tend to skew their needs to male farmers while neglecting the interests of female farmers (Nakazi *et al*., 2017). In this context, women-only CAIs guarantee women's full participation in speaking out to share farming knowledge, experiences and skills in securing the livelihoods and nutritional options for their families (Dohmwirth and Hanisch, 2018).

Conceptual framework: The schematic representation of the conceptual framework of the study is shown in Figure 2. The study underpins the theory of household utility maximization where a household is incentivised to participate in a form of collective action if it optimises its perceived utility (U_{ij}^{Pij}), only if the expected utility (U_i) of participating in a CAI i (C_i^{Pi}) exceeds the perceived utility (U_j) of participating a CAI j (C_j^{Pi}) as expressed in Equation (1).

$$(U_{ij}^{P}) = E_i[U_i C_i^{Pi} X_{Mi}] \geq E_i[U_j C_j^{Pj} X_{Mj}] \qquad (1)$$

where utility (U_i^{Pi}) depends on the expected costs and benefits of participating in CAI i (C_j^{Pj}) and CAI j (C_j^{Pj}) respectively. The costs of collective action participation include membership fees and subscriptions, financial capital and opportunity costs of participating in group activities such as training, extension and advisory services and market days. The benefits of collective action include but are not limited to access to input and output markets, and access to financial services through group savings and credit. The perception and incidence of the costs and benefits are expected to be unevenly distributed across the households due to their divergent socio-economic characteristics including household demographics, farm and farming factors, income, and institutional and infrastructural factors as denoted by X_{Mi} and X_{Mj} respectively.

In turn, it is hypothesised that that the varietal households' socio-economic characteristics are manifested in organizational characteristics of the two CAIs such as membership composition, nature of activities, level of social networking, level of social capital and formalization. The differential transaction-cost-reducing mechanisms are expected to generate differentials in the HFS leveraged across the CAIs along the production and income pathways across the livelihood and efficiency CAIs.



Source*:* Authors' conceptualization

Figure 2. The conceptual framework of the study

MATERIALS AND METHODS

Study area and data*:* The study was conducted in Murang'a County in the Central region of Kenya. The County presents a suitable representative case study based on its prominence in agricultural CAIs that account for about 65 per cent of the total agricultural collectives in the country (KNBS, 2023). Murang'a is also selected because, despite about 80 per cent engaging in agriculture, the county experiences high food insecurity in terms of staples including cereals and pulses (KNBS, 2023). The area also experiences high stunting and wasting of children aged under five, about 20.1 per and 5 per cent respectively, which is slightly higher than the national average of 19.4 per cent and 4.2 per cent respectively (KNBS, 2023). The total sample size constituting collective action members and non-members was computed following Cohen, (1988) normal approximation of binominal distribution (Equation 2).

$$n = \frac{U^2_{1-\alpha/2}\, X\, P(1-P)}{\delta^2} \qquad (2)$$

Where n denotes the number of surveyed households, $U^2_{1-\alpha/2}$ is 1.96 which is the quantile of a standard normal distribution for the 95% confidence interval (at 0.05); P is the proportion of the smallholder households with membership in at least one CAI for one year, which is 0.67; δ is the expected margin of error for any of the parameters to be computed following the survey data. In this study, the expected margin of error was fixed at 0.029, a value that is closer to zero to allow for accurate estimates of the parameters (Cohen, 1988). The value of P was calculated by considering that a single head per household was interviewed given that the aggregate number of agricultural households in the targeted study area is 338695 and the number of households having membership in CAIs was 225,797. The total sample size obtained from Equation 2 is 532 respondents.

A multistage stratified and proportionate random sampling approaches were employed to draw the respondents of the study. In the first stage, two sub counties namely Kandara and Gatanga were selected because of their dominance in CAIs. In the second stage, five wards including two wards from Gatanga sub-county and five wards from Kandara sub-county were selected based on a proportionate random sampling procedure. In the third stage, we employed collective action lists generated by the Ministry of Agriculture, Livestock, Fisheries and Cooperatives of Murang'a County. Then several CAIs were randomly and proportionately sampled to ensure the representativeness of the households across the CAIs following the proportionate sampling formula as shown:

$$n_h = \left({}^{N_h}/_{N}\right) * n. \qquad (3)$$

Where n is the number of different CAIs, N_h is the total number of CAIs in a given Sub-County, N is the total number of CAIs in the county, n is the total number of CAIs in the two Sub-Counties. With the aid of the lists and guidance of the ward-level extension officers, the following CAIs were sampled: 49 producer and marketing groups, 31 savings and credit associations, 5 cooperatives, 2 unions and 10 water and forest user groups. From these CAIs, a total of 353 members were randomly and proportionately sampled according to group sizes in addition to 179 non-members neighboring the respective group members. A well-structured questionnaire was employed to draw cross-sectional data from the respondents from the month of August to October 2022. Before data collection, a research license was issued from the National, Commission for Science, Technology and Innovation (NACOSTI). The collected data included types and frequencies of different food groups consumed by the households within the last seven days preceding the survey, household demographics, farm and farming factors, institutional and infrastructural factors and income.

***Measurement of household food security*:** The study employed the Food Consumption Score (FCS) as an indicator for HFS. The FSC is a weighted score based on food frequency and dietary diversity of the food groups consumed within the last seven days before the survey (World Food Programme, WFP, 2015). The FCS of a household was calculated by multiplying the frequency of foods consumed in the last seven days with the weights of each food group as expressed in equation (2).

$$\begin{aligned} FCS &= \beta_{istaple}X_{istaple} + \beta_{ipulse}X_{ipulse} + \beta_{iveg}X_{iveg} \\ &+ \beta_{ifruit}X_{ifruit} + \beta_{imeateggfish}X_{imeateggfish} + \beta_{isugar}X_{isugar} \\ &+ \beta_{imilk}X_{imilk} \\ &+ \beta_{ioil}X_{ioil} \end{aligned} \qquad (4)$$

where; β_i is the frequency of consumption; X_i denote the weight of each food group for staples, pulses, vegetables, fruits, meat/egg/fish, sugar and oil. The sum scores were then used to determine the FCS, with the maximum score value of 112 which would be achieved if the household ate each group of food every seven days preceding the survey. Consumption scores of 0 to 21 were stratified as chronic food insecurity,

21.5 to 35 were classified as transitory food insecurity and more than 35 were categorized as food secure.

***Determinants of household food security differentials in efficiency and livelihood CAIs*:** A pooled regression where a dummy binary collective action participation variable may not be appropriate because it fails to provide a real account of the interactions between the two forms of CAIs and the household socio-economic attributes in the model. This is because a pooled regression assumes that the set of covariates has the same effect on HFS for both livelihood CAIs and efficiency CAIs. An ordered probit model is appropriate because the HFS outcomes are ordinal and it assumes that there exist cut-offs between the food security outcomes across the efficiency and livelihood CAIs (Lutomia *et al*., 2019). Consider three observed categories of self-reported food security status with y_i as the underlying latent ordered food security status categorical outcome is expressed as:

$$y_i = X_i^T\beta + \varepsilon_i \quad (5)$$

where $X_i = (1, x_{i1,} \ldots . x_{ij}, \ldots . . x_{im)}^T$ is the vector of covariates for the ith household (i=1,….,n and j=1,…..,m); n is the total number of observations; m is the number of socio-economic variables; x_{ij} is the value of jth variable for the ith household; $\beta = (\beta_0, \beta_{1,} \ldots . \beta_{j,}, \ldots . . \beta_{m),}^T$ is the vector of coefficients and ε_i is the random error term that follows a standard normal distribution. The value of the HFS status y_i is then determined as:

$$z_i \begin{cases} 1 \text{ if } z_0 < y_i \leq z_i \\ K \text{ if } z_{K-1} < y_i \leq z_K \\ C \text{ if } y_{c-1} < y_i \leq z_C \end{cases} \quad (6)$$

where Z $(z_{0,} \ldots . z_K, \ldots . . z_{c)}$ are the threshold values for all the HFS categories. $z_{0,}$ and z_c are defined as $(-\infty \text{ and } +\infty)$, respectively. The rest of the threshold values are subject to the constraint $y_i \leq \cdots \ldots z_i \leq z_K \leq z_{C-1}$. Given the value of X_i, the probability that the household i belongs to each HFS category is:

$$p(z_i = 1) = \Phi(z_i - X_i^T\beta)$$
$$p(z_i = K) = \Phi(z_k - X_i^T\beta) - \Phi(z_{k-1} - X_i^T\beta)$$
$$p(z_i = C) = 1 - \Phi(z_{c-1} - X_i^T\beta) \quad (7)$$

where, $\Phi(\ldots)$ denotes the cumulative probability function of the standard normal distribution.

***Effect of efficiency and livelihood CAIs on household food security along the pathways of production and income*:** To estimate the effect of collective action on HFS the study employed a multinomial endogenous treatment effects model (METE) (Deb and Trivedi, 2006b). METE was selected because it employs a joint two-step estimation process in accounting for endogeneity problems that arise from the reverse causality between collective action participation and the HFS status. The first step entails a selection equation based on a multinomial logit model that examines the household's collective action participation decisions. The second step is a METE outcome equation that examines the effect of collective action participation on HFS among the members of the livelihood and efficiency CAIs where non-members are the reference group. In accessing the effect of HFS we include the indicators of HFS along the pathways of agricultural, income and the overall HFS through the combination of income and production pathways. On the agricultural pathways, we consider the indicators of quantity of maize and beans output (the two most important staple crops in the study area) to reflect the effect of food availability effect of the CAIs.

Household income and food expenditure are considered in accounting for the economic access to food effect of CAIs. The overall HFS effects through the combined pathways of production and income were estimated by including the quantity of beans and maize, household income and food expenditure. The indicators of the aforementioned pathways were included alongside other covariates in the METE outcome equation. The probability of observing a farmer participating in a collective action typology j follows a mixed multinomial distribution as follows: Following Deb and Trivedi (2006b), let *i* denote non-members of the two CAIs and $U_{ij}^* = 0$. While U_{ij}^* is not observed, it can be represented as a set of dichotomous variables c_j and it can be designated by a vector $c_j = c_{j1}, c_{j2}, c_{j3} \ldots . c_{jJ}$. Also, let $l_j = l_{j1}, l_{j2}, l_{j3} \ldots . l_{jJ}$. The treatment probability follows a mutually exclusive choice as shown in Equation (6).

$$\Pr(c_{ij} | z_j' | l_j) = \frac{\exp(z_j'\alpha_1 + \delta_j l_{ij})}{1 + \sum_{k-1}^{J} \delta_{ik} \exp(z_i'\alpha_i + \delta_i l_{ji})} \quad (8)$$

where, c_{ij} is the likelihood of a household to choose a CAI depending on z_i socio-economic characteristics of i^{th} farmer and latent factors l_{ij} with their associated loadings (δ_j) which represents the unobserved collective action heterogeneity affecting the utility obtained from a given CAI. The expected outcome of HFS is estimated by METE in the second stage as follows:

$$\Pr(y_j | x_j | l_j) = z_j'\beta + 1 + \sum_{i-1}^{J} \Upsilon_i \; c_{ii} + \sum_{i-1}^{J} \lambda_i \; c_{ii} \quad (9)$$

y_i is the HFS outcome; x_i denotes a vector of exogenous covariates with their parameter estimators β. Υ_i are the treatment effects of participating in CAIS (I=1,2) compared to the non-members (i=0). Collective action participation is endogenous and assumes that c_j is exogenous, it would yield biased and inconsistent estimates of Υ_i. We address this issue using the exclusion restriction instrumental variables approach. Following Magambo *et al*. (2022), the instrumental variables selected met the following conditions: they were sufficiently correlated with CAI choice variables (z_i); they were correlated with unobservable variables affecting HFS (l_i) and they were uncorrelated with HFS y_i, except through collective action participation variables (z_i) The instrumental variables that met these criteria included access to

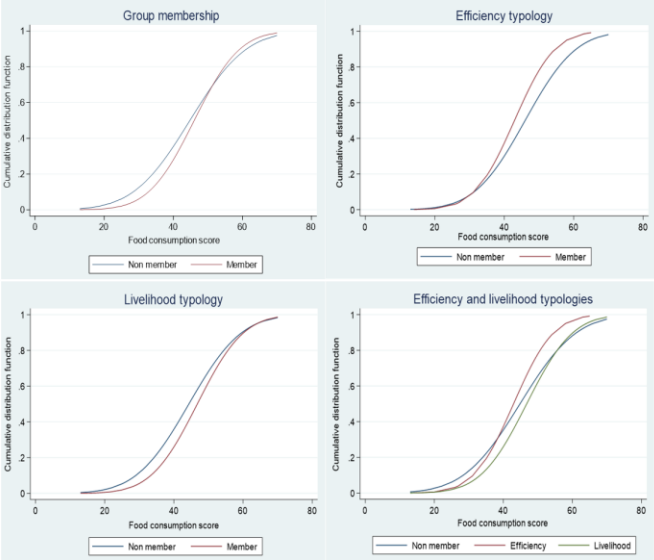
information, communication and technology (ICT), access to electricity and the total number of CAIs the farmer is aware of. We validated our instrumental variables by implementing the likelihood ratio (LR) test which tests the joint significance of the instrumental variables. The instrumental variables with a significant F statistic of Prob > F that is ≥ 10 is regarded as strong (Magambo *et al*., 2022).

The multinomial logit model assumes that the probability of any treatment outcomes is determined independently of any other available outcomes, therefore, we tested for IIA assumption using the Hausman test (Deb and Trivedi, 2006b). The insignificant value indicates no evidence that the IIA assumption is violated (Greene, 2016). The study also conducted a post-test of exogeneity for treatment, which tests for the joint hypothesis that the loading parameters (λ) for efficiency and livelihood CAIs are equal to zero. If the test is significant ($p< 0.05$), the null hypothesis of exogeneity is rejected, indicating that the treatment variable is endogenous. Before running the METE model, the multicollinearity test was conducted to test whether the multicollinearity inflates the variance of the predictors (Greene, 2016). The threshold variance inflation factor (VIF) of less than 5 rejects the hypothesis that the multicollinearity inflates the variance of the predictors

RESULTS AND DISCUSSION

***Descriptive statistics*:** The variable descriptions and descriptive statistics for the households are presented in Table 1. The households sampled included 289 members of livelihood CAIs, 64 members of efficiency CAIs and 179 non-members. Contrary to the livelihood CAIs, the efficiency CAIs constituted of older males, owning larger farm sizes with longer experience in farming and producing more beans. In addition, compared to the livelihood members, the efficiency members showed a high level of awareness of the CAIs within their neighborhood, more access to banking services, information and contacts with extension service providers. On the other hand, the livelihood CAIs constituted women with larger household sizes that were located near tarmac roads. The members of the livelihood CAIs also had more sources of household income and engaged more in non-farm economic activities. Given the smaller farm sizes among the livelihood members, engagement in off-farm activities was important for the livelihood members in supplementing household incomes.

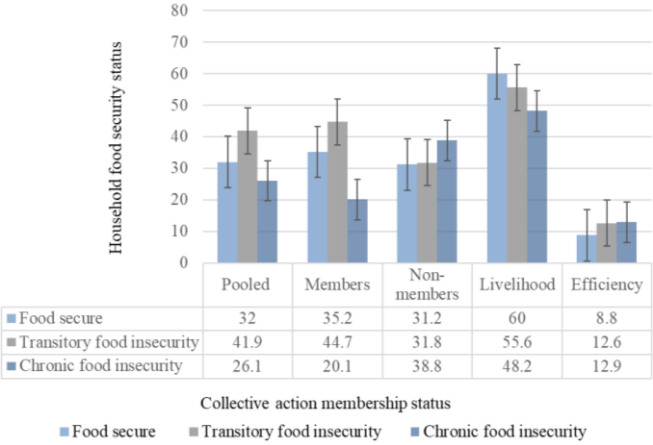
Food security statuses of the households: Figure 3 shows the overall HFS statuses disaggregated by the collective action membership. The households that belonged to either livelihood or efficiency CAIs were significantly more food secure than the non-members. However, the non-members had a higher FCS compared to members of the efficiency CAIs. Similarly, the members of the livelihood CAIs were more food secure than non-members. Overall, members of the livelihood CAIs had higher FCS closely followed by the non-members and the efficiency members who reported the lowest FCS.



Source: Authors' field data

Figure 3. Overall statuses of HFS following collective action membership

Figure 4 disaggregates the categories of HFS following collective action membership. On the pooled sample, a large proportion of the farmers (about 41.9%) were categorized as transitory food insecure closely followed by food secure households (32%) and chronically food insecure farmers (26.1%).



Source: Authors' field data

Figure 4. Disaggregation of HFS categories following collective action participation

From the results, the collective action members were more food secure than the non-members wherein the majority of the farmers were transitory food insecure. Similarly, the majority

of the collective action non-members belonged to the chronically food insecure category, signifying the importance of the CAIs in improving HFS. In comparing the efficiency and livelihood CAIs, although both livelihood and efficiency are categorized under transitory food secure, the livelihood members revealed significantly and slightly higher food consumption score than their efficiency counterparts (Table 1).

The livelihood members also exhibited higher food security where about 60% of its members were classified as food secure compared to the efficiency members (8.8%). This can be partly explained by the significantly higher food expenditure spent by the livelihood members than the efficiency members (Table 1). A large proportion of the efficiency members (12.9%) were chronically food insecure than the farmers who were food secure (8.8%).

Table 1. Descriptive statistics and description of variables for the livelihood and efficiency collective action initiatives.

Variables	Description	Livelihood (1)		Efficiency (2)		Difference
		Mean	Std.Dev	Mean	Std. Dev	(2)-(1)
Household food security indicator						
FCS	Food consumption score	31.66	11.26	27.25	9.60	-2.91***
Household demographics						
Age	Age of the household head (years)	55.13	13.19	62.72	11.69	4.25***
Gender	Gender of the household head (1=male)	0.66	0.05	0.84	0.03	2.33**
Education	Education level of the household head	2.55	0.84	2.58	0.84	0.21
Household size	Total family size (number)	3.89	1.88	3.29	1.96	-2.28**
Literacy ratio	Household members with secondary education and above	2.54	1.85	2.69	1.87	0.59
Dependency ratio	Ratio of dependents to the family size	1.16	1.29	0.89	0.79	-1.42
Farm and farming characteristics						
Farm size	Size of the farm (acres)	1.03	1.03	1.41	0.87	2.75***
Livestock	Livestock Tropical Units (LTU)	1.84	2.57	2.42	3.89	1.46
Farming experience	Years of farming	22.83	14.77	26.86	14.51	1.98**
Farm labour	Ratio of household members providing farm labour	0.97	0.71	1.055	0.73	0.91
Infrastructure and institutions						
Market	Self-reported walking distance to the nearest market (kilometres/km	3.35	2.06	3.45	3.61	0.32
Tarmac road	Self-reported walking distance to the nearest tarmac road (km)	1.79	1.48	2.24	2.53	1.87*
Extension	Self-reported walking distance to the nearest extension office (km)	3.43	2.24	3.63	3.34	0.59
Extension contacts	Number of extension contacts	1.02	2.62	3.27	4.18	5.49***
Piped water	The household has piped water (1=yes)	0.51	0.50	0.58	0.50	1.06
Information	Number of sources of agricultural information	2.41	1.17	3.64	1.62	7.03***
ICT	Access to information, communication and technology (ICT)	0.34	0.47	0.30	0.46	-0.65
Awareness of CAIs	Awareness of the types of CAIs in the neighbourhood (number)	3.24	0.08	4.11	0.14	4.62***
Electricity supply	Household has electricity supply (1=yes)	0.85	0.36	0.88	0.33	0.49
Household income and assets						
Assets	Total asset value (Kenyan shillings/KES)	123356.6	431673.2	115833.9	279813.6	-0.13
Bank account	Household has a bank account (1=yes)	0.45	0.50	0.83	0.38	5.66***
Credit access	Household access to credit (1 =yes)	0.65	0.48	0.53	0.50	-1.74*
Income sources	Number of household income sources	1.60	0.74	1.33	0.54	-2.75***
Farm income	Aggregate income earned from all farming activities (KES)	50991.71	56814.08	41739	44452.58	-1.02
Off-farm income	Household earns non-farm income (1=yes)	0.55	0.49	0.27	0.45	-4.21***
Production pathway indicators						
Maize produced	Quantity of maize produced (kilograms)	219.33	348.02	297.68	440.16	1.40
Beans produced	Quantity of beans produced (kilograms)	60.15	97.04	110.39	181.60	2.40*
Income pathway indicators						
Household income	Range of household income (KES)	1.44	0.06	1.66	0.15	1.56
Food expenditure	Food expenditure per week (KES)	1948.61	79.10	1625.78	138.27	-1.79*

Significance levels *** p< 0.01, ** p< 0.05, * p< 0.1

Education level of the household head (1=Primary, 2=secondary 3=vocational 4=University); Std. Dev = Standard deviation; Source: Authors' field data

***Determinants of differential food security statuses across the efficiency and livelihood CAIs*:** The multicollinearity test results revealed that the variance inflation factor was 1.98 which is less than the recommended threshold of 5 (Greene, 2016). Therefore, the study rejected the null hypothesis that the multicollinearity inflates the variance of the predictors. Estimated parameters for determinants of food security for efficiency and livelihood CAIs are presented in Table 2 and Table 3 respectively.

The study reports the average marginal effects (AME) and the robust standard errors. As shown in Table 2 and Table 3, the AME results of the covariates that explain the status of HFS are different between livelihood CAIs and efficiency CAIs.

The Wald chi^2 statistics tests are significantly different at the 1% level (Wald chi2(21) =104.37; Wald chi2(21) =57.09 for livelihood and efficiency CAIs respectively). This implies that disaggregating the data based on the type of CAIs is more appropriate than incorporating collective action as a dummy variable or arbitrarily pooling the CAIs.The results revealed that household size reduces the risk of food insecurity among the efficiency and livelihood members. This finding supports Kehinde *et al*.(2021) who found a positive correlation between household size and HFS in Kenya. Household size is an indicator of the availability of agricultural labour that would offset the opportunity costs of participating in collective training, meetings and market days that would improve HFS through the effects of own production and sale of farm surplus.

As expected, the farm size increased the probability of food security by 6.9% while it reduced the likelihood of being chronically food insecure by 15.7%. However, farm size showed a negative and non-significant effect on the status of HFS among the livelihood members. Members of efficiency CAIs had larger farm sizes compared to the livelihood members that had limited production capacities due to smaller farm sizes. Land tenure, which is ownership of land with title

Table 2. Ordered probit model: Determinants of household food security among the efficiency collective action initiatives.

	Food secure			Transitory food insecure			Chronic food insecure		
	AME	**Std. error**	**P > z**	**AME**	**Std. Error**	**P > z**	**AME**	**Std. Error**	**P > z**
Household demographics									
Age	-0.012**	0.005	0.021	-0.015***	0.005	0.002	0.027***	0.007	0.000
Gender	0.077	0.095	0.420	0.097	0.113	0.391	-0.174	0.203	0.391
Education	-0.091**	0.036	0.011	-0.115*	0.065	0.075	0.206**	0.084	0.014
Household size	0.038**	0.016	0.019	0.048*	0.024	0.048	-0.086***	0.033	0.009
Farm and farming factors									
Farm size	0.069***	0.025	0.005	0.088*	0.053	0.098	-0.157**	0.067	0.019
Land tenure	-0.102***	0.038	0.008	-0.130***	0.043	0.003	0.231***	0.050	0.000
Livestock	0.036**	0.014	0.013	0.046*	0.025	0.066	-0.082**	0.329	0.012
Farming experience	0.004	0.003	0.133	0.005*	0.003	0.050	-0.010*	0.005	0.051
Farm labour	0.190***	0.068	0.005	0.242	0.161	0.134	-0.432**	0.207	0.036
Infrastructure and institutions									
Market	-0.013	0.012	0.293	-0.016	0.020	0.419	0.029	0.031	0.357
Tarmac road	0.012	0.012	0.327	0.016	0.019	0.403	-0.028	0.030	0.358
Extension contacts	0.013*	0.007	0.076	0.017*	0.009	0.053	-0.030*	0.014	0.030
Piped water	-0.011	0.077	0.888	-0.013	0.102	0.892	0.025	0.179	0.890
Information	-0.051***	0.015	0.001	-0.065**	0.036	0.075	0.116***	0.044	0.008
ICT	0.065	0.069	0.344	0.083*	0.066	0.211	-0.148	0.130	0.255
Household income and assets									
Credit access	-0.188***	0.069	0.006	-0.239	0.149	0.109	0.426**	0.190	0.025
Farm income	0.000**	0.000	0.022	0.000***	0.000	0.001	-0.000***	0.000	0.000
Off-farm income	0.102*	0.050	0.043	0.129*	0.099	0.196	-0.231*	0.139	0.098
Production pathway indicators									
Maize produced	-0.000	0.000	0.167	-0.000	0.000	0.254	0.000	0.000	0.190
Income pathway indicators									
Household income	0.044*	0.027	0.098	0.056	0.040	0.167	-0.100	0.615	0.103
Food expenditure	-0.000	0.000	0.577	-0.000	0.000	0.531	0.000	0.000	0.547
Regression diagnostics									
Wald chi2(21)	57.09								
Prob > chi^2	0.000								
Pseudo R^2	0.517								

Significance levels *** p< 0.01, ** p< 0.05, * p< 0.1;

AME=Average marginal effects; Std. Error =standard error; Std. Error =Standard error; Source: Authors' field data

Table 3. Ordered probit model: Determinants of household food security among the livelihood collective action initiatives.

	Food secure			Transitory food insecure			Chronic food insecure		
	AME	**Std. error**	**P > z**	**AME**	**Std. error**	**P > z**	**AME**	**Std. error**	**P > z**
Household demographics									
Age	-0.001	0.003	0.818	0.000	0.001	0.819	0.001	0.002	0.818
Gender	0.012	0.052	0.824	-0.002	0.011	0.825	-0.009	0.042	0.824
Education	0.020	0.033	0.539	-0.004	0.007	0.538	-0.016	0.026	0.541
Household size	0.020*	0.012	0.099	-0.004	0.003	0.124	-0.016	0.010	0.104
Farm and farming characteristics									
Farm size	-0.005	0.026	0.839	0.001	0.005	0.840	0.004	0.020	0.839
Land tenure	-0.098***	0.021	0.000	0.020***	0.008	0.009	0.078***	0.016	0.000
Livestock	0.001	0.010	0.909	-0.002	0.002	0.909	-0.001	0.008	0.909
Farming experience	0.002	0.002	0.514	-0.000	0.001	0.526	-0.001	0.002	0.513
Farm labour	-0.011	0.037	0.769	0.002	0.008	0.772	0.009	0.029	0.768
Infrastructure and institutions									
Market	-0.011	0.014	0.431	0.022	0.003	0.440	0.009	0.11	0.432
Tarmac road	-0.010	0.018	0.554	0.002	0.004	0.550	0.008	0.014	0.556
Extension contacts	-0.019	0.012	0.126	0.004	0.003	0.167	0.015	0.010	0.126
Piped water	-0.092*	0.049	0.061	0.019	0.012	0.113	0.073*	0.039	0.059
Information	0.023	0.017	0.188	-0.005	0.004	0.206	-0.018	0.014	0.193
ICT	0.282***	0.052	0.000	-0.058***	0.018	0.002	-0.224***	0.046	0.000
Household income and assets									
Bank account	-0.003	0.051	0.947	0.001	0.011	0.947	0.003	0.041	0.947
Credit access	-0.006	0.048	0.903	0.001	0.010	0.903	0.005	0.038	0.902
Income	0.017	0.033	0.609	-0.003	0.007	0.615	-0.013	0.026	0.609
Off-farm income	0.088*	0.047	0.059	-0.018	0.011	0.101	-0.070*	0.037	0.060
Production pathway indicators									
Maize produced	0.000**	0.000	0.018	-0.000*	0.000	0.053	-0.000**	0.000	0.019
Income pathway indicators									
Household income	0.017	0.033	0.609	-0.003	0.007	0.615	-0.013	0.026	0.609
Food expenditure	-0.000***	0.000	0.001	0.000**	0.000	0.024	0.000***	0.000	0.000
Regression diagnostics									
Wald chi2(21)	104.370								
Prob > chi^2	0.000								
Pseudo R^2	0.192								
Log pseudolikelihood	-213.256								

Significance levels *** p< 0.01, ** p< 0.05, * p< 0.1;
AME=Average marginal effects; Std. Error =standard error; Source: Authors' field data

deeds among the two CAIs increased the likelihood of being food insecure for both efficiency and livelihood members. The marginal effects for the efficiency CAIs were higher than the livelihood CAIs. This finding could be attributed to the fact that due to market-oriented production among the efficiency CAIs. Land tenure increases long-term agricultural investment prospects that could enhance production and incomes (Fischer and Qaim, 2012a).

On efficiency CAIs, livestock showed positive effects on both food security and transitory food security. Livestock provides animal proteins for own consumption as well as a diversification strategy where animals can be sold to smooth consumption during food shortfalls. The results on efficiency CAIs further revealed that an increase in age reduces the likelihood of being food secure among the efficiency CAIs while age increases the propensity of being chronically food insecure. Wegi *et al*. (2023) contend that the negative association between the age of the household head and HFS could be due to a decline in productivity resulting from the ageing of the household head.

Availability of farm labour increases the probability of food security and transitory food security and decreases the likelihood of chronic food insecurity among the efficiency CAIs. This finding is consistent with Lutomia *et al*. (2019) that the availability of farm labour could increase the production of food and market participation. This is important, particularly among the members of efficiency CAIs given that they practice market-oriented and standardised production that requires intensive labour. Holding all other factors constant, access to information had a negative effect on food security and transitory food security but showed a positive effect on chronic food security among the members of efficiency CAIs. The efficiency members had more access to information than the livelihood members. In

Table 4. Household food security effects across the efficiency and livelihood CAIs.

Accounting for endogeneity						
Pathway	**Efficiency**			**Livelihood**		
	Coefficient	**Std. Error**	**P > z**	**Coefficient**	**Std. Error**	**P > z**
Production	0.352***	0.005	0.000	0.577***	0.004	0.000
Income	-0.114***	0.005	0.000	0.385***	0.004	0.000
Combined pathways	0.244***	0.010	0.000	0.453***	0.005	0.000
λ Production	0.012***	0.132	0.000	-0.718***	0.001	0.000
λ Income	0.408***	0.001	0.000	-0.560***	0.001	0.000
λ Combined pathways	0.180***	0.002	0.000	-0.648***	0.002	0.000
Assuming exogeneity						
Pathway	Efficiency			Livelihood		
	Coefficient	Std. Error	P > z	Coefficient	Std. Error	P > z
Production	0.778***	0.004	0.000	-0.031***	0.003	0.000
Income	0.556***	0.007	0.000	-0.211***	0.007	0.000
Combined pathways	0.119	0.262	0.649	0.278	0.245	0.257
λ Production	-0.672***	0.000	0.000	-0.025***	0.002	0.000
λ Income	-0.674***	0.002	0.000	0.103***	0.003	0.000
λ Combined pathways	0.284	0.278	0.307	-0.424	0.297	0.153

400 Halton sequence-based quasirandom draws per observation used

Significance levels *** p< 0.01, ** p< 0.05, * p< 0.1; Base category = Nonmembers; Source: Authors' field data

most cases, the farmers collectively received income-generation-oriented information on production practices, market dynamics, risk coping and risk aversion strategies. However, limited dissemination of nutritional information in the area could compromise with HFS benefits leveraged. Regarding education, holding other factors constant, education reduced the likelihood of being food secure while it had a positive effect on chronic food security among the efficiency CAIs. Contrary to the livelihood CAIs, extension contacts reduced the risk of food insecurity among the members of efficiency CAIs.

Regarding off-farm income, it reduces the vulnerability to food insecurity among the members of the livelihood and efficiency CAIs. This finding is plausible and aligns with the field interviews that off-farm engagements supplement farm income and buffer the households during risks and shocks including crop failure, supply chain disruptions and increases in food prices (Mutungi *et al*., 2023). Access to credit among the efficiency CAIs reduced the likelihood of the efficiency members being food secure and transitory food insecure by 18.8% and 23.9% respectively while increasing the risk of being chronically food insecure by 42.4%.

This finding is consistent with Niles *et al*. (2021) who found that access to credit can increase the vulnerability of households to food insecurity due to inability to repay. This finding can also be attributed to the likelihood of the efficiency members investing the credit received in improving cash crop production through the acquisition of improved farm inputs and technologies as well as offsetting the collective marketing transaction costs. Table 2 and Table 3 results shows that food expenditure had a negative effect on food security and increased the chances of being transitory food insecure among the livelihood CAIs. On the contrary, the efficiency members revealed non-significant food expenditure effects on HFS.

This finding was expected because the allocation of food expenditure was significantly higher for the livelihood members than the efficiency members. However, the negative effects of food security could be attributed to liquidity and budgetary constraints leading to diverting of the income to non-food items such as meeting the collective action financial obligations such as repayment of loans and contributions to the savings, credit and informal insurance kits. The quantity of maize produced positively influenced the HFS among the livelihood CAIs, but it revealed a non-significant effect on the efficiency members. This result was unexpected because the efficiency members produced more quantity of maize than their livelihood counterparts. The members of the efficiency CAIs could have opted to sell their maize, unlike the members of the livelihood CAIs that utilised the maize for home consumption to improve the food self-sufficiency of their households. Regarding farm income, it positively influenced food security and reduced the risk of chronic food security among the efficiency members. Contrariwise, farm income did not show any effect on HFS among the livelihood members. Access to ICT positively influenced HFS among the livelihood members. ICT facilitates in co-ordination of group activities such as meetings and collective mobile phone financial transactions such as savings, rotating credit sourcing and reciprocal or collective asset acquisition.

***Effect of efficiency and livelihood CAIs on household food security along the pathways of production and income*:** The

METE model pre-test and post-test results are shown in the appendices. The Hausman test was used to check the independence for irrelevant alternatives (IIA) was insignificant, indicating no evidence that the IIA assumption was violated (Greene, 2016). The instrumental variables were regarded as strong $F(3, 528) = 37.17$; $Prob > F = 0.000$ since F statistics is ≥ 10 (Magambo *et al*., 2022). Table 4 presents the effects of collective action on HFS among the efficiency and livelihood CAIs. The full results reflecting the HFS along the nutritional pathways of production and income are shown in the appendices section. Table 4 presents a set of results that account for endogeneity and another set that assumes exogeneity, but we strictly interpret our results that account for endogeneity. The likelihood ratio test values for the exogeneity tests for the results accounting for endogeneity were significant ($p< 0.05$), therefore, the null hypothesis of exogeneity was rejected and the treatment variable was endogenous across the two nutritional pathways hence this justifies the application of METE model. Relative to non-members, participation in efficiency and livelihood CAIs had a positive effect on HFS. This finding aligns with Shumeta and D'Haese (2018) who found positive effects of production on HFS among the Ethiopia coffee cooperatives.

Since most of the farmers in the study area derive the largest proportion of their food from their production, the positive effect of the efficiency and livelihood of CAIs could be attributed to the multipurpose nature of the CAIs. The CAIs provide a suitable environment for food production through the dissemination and acquisition of inputs, particularly chemical fertilizer and improved seeds at a fair price. The CAIs also provide post-harvest loss management education and improved storage of hermetic bags that are important in preserving the staples' quality and quantity. The CAIs also helped the farmers in agricultural planning by synching their production with the weather patterns to minimize crop failure. The lower effect observed on efficiency CAIs could be explained by the tendency to sell part of the staple surplus arising from the higher yields. Analogously, the livelihood members compensated for the production gaps arising from smaller land sizes by engaging in non-farm wage employment and small entrepreneurship businesses to generate off-farm incomes that they reinvest in the acquisition of food items. The selection term for the lambda for the efficiency CAIs is positive, indicating that the farmers who are more likely to self-select to become efficiency members based on their unobserved attributes are likely to be food insecure through production.

Regarding income pathway, the efficiency CAIs were found to have a negative effect on HFS through income and food expenditure. This finding was unexpected because of the high bridging social capital among the efficiency CAIs that facilitate in creating of market linkages for the members to increase production, commercialization of farm produce and household income. The negative income effect is more likely to be ascribed to the spillover effect of insignificant differences in income between the livelihood members and efficiency members. This difference can arise due to difficulties in accessing the capital outlay for collective marketing, higher rejection rates of the produce due to failure to meet the designated production standards, corruption, low managerial capacity and delayed payments for the farmers' collective sales.

Additionally, the efficiency CAIs purchase additional foods (such as animal protein, cooking oil, sugar and rice) that are not produced from their farms, but the expenditures are not significantly influenced by membership in efficiency CAIs. The farmers' liquidity and budgetary constraints compromise expenditure on food and farmers are more likely to invest their income on non-food items such as education, large household expenditure and housing. Aligning with Fischer and Qaim (2012a), the negative effect could also probably emanate from the limited control of women over household incomes that could lower their purchasing power of food items, a phenomenon that can be plausible given that the efficiency CAIs are dominated by men.

On the other hand, the livelihood CAIs showed positive effects of income of HFS. This implies that the savings and credit acquired from the group among the livelihood CAIs increase the purchasing power of the diverse diets. This finding is supported by the significantly higher food expenditure incurred by the livelihood members than the efficiency members. On the combined pathways of income and production, relative to non-members, membership in efficiency CAI and livelihood CAIs increased HFS by 24.4% and 45.3% respectively.

The overall HFS effects among the two combined pathways were smaller compared to the effects observed on the production pathway. These findings support Shumeta and D'Haese (2018) who found lower overall HFS effects across the combined pathways of income and production among the coffee cooperatives in Ethiopia. The HFS effects were much higher for the livelihood CAIs than the efficiency CAIs due to the trade-off of the negative income effects on HFS among the efficiency CAIs. Similarly, the higher overall HFS effects among the livelihood CAIs arise from the synergistic effects accrued from production and income. Additionally, the higher HFS effects could be attributed to the dominance of women in livelihood CAIs, who according to (Quisumbing *et al*., 2021) play key roles in securing HFS through production, generation of incomes, domestic work and caregiving responsibilities. However, from the findings, the lower overall HFS effects along the two combined pathways among the livelihood CAIs compared to the HFS effects along the production pathway would be attributed to the trade-off income effects on HFS. This implies that the synergies between the income effects and production effects were lower probably due to sub-optimal expenditure on food emanating from the diversion of incomes to meeting the collective

financial obligations of saving, credit, asset acquisition and informal insurance kits.

***Conclusion and policy implications*:** This study explored the effects of socio-economic context-specificity of efficiency and livelihood CAIs on HFS along the pathways of production and income. We employed the ordered probit model and METE model in empirical analysis. The findings showed a significant difference in HFS status between efficiency and livelihood CAIs. The differentials in HFS across the CAIs were attributed to differences in age, education, farm size and livestock ownership, household size, farm labour, access to information and credit and extension contacts. The differences in HFS can also be accounted for by the heterogeneities in group composition, functions and social capital across the CAIs that determine their capacity to leverage HFS benefits along the pathways of production and income. Participation in efficiency and livelihood CAIs had a significant effect on HFS through production. Contrary to the livelihood CAIs, the efficiency CAIs showed a negative HFS effect through income. The overall HFS across the combined pathways of income and production was low for both efficiency and livelihood CAIs due to the trade-offs exhibited through the income effects. However, the effects were lower for the efficiency CAIs than the livelihood CAIs due to the negative income effects exhibited by the former while and the synergies arising from income and production on the latter. The findings suggest the overall performance of both efficiency and livelihood CAIs in leveraging HFS from joint income and production remains tentative. These findings have key implications on the interventions designed to influence HFS trajectories. Therefore, the study debunks a one-size-fits-all policy and program design approaches in promoting the development of the CAIs for improved HFS.

The study suggests a portfolio of collective action policies and interventions that are context-specific in matching the diversity of the households and the differentials of the efficiency and livelihood CAIs and their links to HFS along the production and income pathways. The policies would confer potential synergies, spillover effects and complementarities in strengthening the synergies while mitigating the trade-offs along the income and production pathways between the efficiency and livelihood CAIs. There is a need to incentivize the non-farm livelihood-enhancing economic activities among the livelihood members to fill the household food gaps arising from low production. This is through creating a conducive environment for the livelihood CAIs to easily access affordable loans and credit with flexible terms of payment and affordable interest rates. It is important to establish micro-credit schemes and collective action funds for both efficiency and livelihood CAIs. This would help to tap opportunities for credit sourcing and pooling savings among the livelihood members while promoting collective input sourcing and output marketing among the efficiency CAIs. There is a need to enhance access to information, extension and advisory services and information, communication and technology (ICT) among the members of the livelihood CAIs to improve production. Nonetheless, there is a need for extensive similar studies to extend the empirical findings in broader socio-economic settings. It is also important to employ panel data to ascertain how the transformation trajectories of the CAIs influence HFS over time because CAIs are dynamic entities and HFS is highly sensitive to seasons.

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***SDG's Addressed*:** Zero Hunger

REFERENCES

Andersson, E. and S. Gabrielsson. 2012. Because of poverty, we had to come together: Collective action for improved food security in rural Kenya and Uganda. International Journal of Agricultural Sustainability 10:245-262.

Bernard, T. and A. S. Taffesse. 2012. Returns to scope? Smallholders' commercialisation through multipurpose cooperatives in Ethiopia. Journal of African Economies 3:440-464.

Cohen, J. 1988. Statistical Power Analysis for the Behavioural Sciences.

Cramer, L., W. Förch, I. Mutie and P. K.Thornton. 2016. Connecting Women, Connecting Men: How Communities and Organizations Interact to Strengthen Adaptive Capacity and Food Security in the Face of Climate Change. Gender, Technology and Development 20:169-199.

Deb, P. and P. K.Trivedi. 2006b. Specification and simulated likelihood estimation of a non-normal treatment-outcome

model with selection: Application to health care utilization. Econometrics Journal 9: 307–331.

Dhal, S., L. Lane and N. Srivastava 2020. Women's Collectives and Collective Action for Food and Energy Security: Reflections from a Community of Practice (CoP) Perspective. Indian Journal of Gender Studies 27:55-76.

Dohmwirth, C. and M. Hanisch. 2018. Women and collective action: Lessons from the Indian dairy cooperative sector. Community Development Journal 53:1-19.

Fischer, E. and M. Qaim. 2012a. Gender, agricultural commercialization, and collective action in Kenya. Food Security 4:441-453.

Fongar, A., T. Gödecke and M. Qaim. 2019. Various forms of double burden of malnutrition problems exist in rural Kenya. BMC Public Health 19:1-9.

Food and Agricultural Organization. 2023. The State of Food Security and Nutrition in the World 2023. Urbanization, agrifood systems transformation and healthy diets across the rural–urban continuum.

Ganle, J.K., K. Afriyie and A.Y. Segbefia. 2015. Empowerment and disempowerment of rural women in Ghana. World Development 66:335-345.

Greene. 2016. Econometrics Analysis.

Gyau, A., M. Mbugua and J. Oduol. 2016. Determinants of participation and intensity of participation in collective action: Evidence from smallholder avocado farmers in Kenya. Journal on Chain and Network Science 16:147-156.

Harris-Fry, H., N. Shrestha, A. Costello and N. M. Saville. 2017. Determinants of intra-household food allocation between adults in South Asia - A systematic review. International Journal for Equity in Health 16:1-21.

Hintz, K.S. and J. Pretzsch. 2023. Co-creation of business models for smallholder forest farmers' organizations: Lessons learned from rural Ethiopia and Tanzania. Annals of Public and Cooperative Economics 4:1-29.

Kaiser, M., S. Barnhart and S. Huber-Krum. 2020. Measuring Social Cohesion and Social Capital within the Context of Community Food Security: A Confirmatory Factor Analysis. Journal of Hunger and Environmental Nutrition 15:591-612.

Kehinde, A.D., R. Adeyemo and A. A. Ogundeji. 2021. Does social capital improve farm productivity and food security? Evidence from cocoa-based farming households in Southwestern Nigeria. Heliyon e06592.

Kenya National Bureau of Statistics. 2023. Demographic and Health Survey 2022. In Demographic and Health Survey 2022.

Kihiu, E.N. and F. Amuakwa-Mensah. 2021. Agricultural market access and dietary diversity in Kenya: Gender considerations towards improved household nutritional outcomes. Food Policy 100:2019-2021.

Kirimi, L., R. Gitau and M. Olunga. 2013. Household Food Security and Commercialization Among Smallholder Farmers in Kenya. 4th International Conference of the African Association of Agricultural Economists 2015:1-20.

Koster, T., E.Termeer, N. Motovska, M.O. Kunz and I. Ayuya. 2021. Social capital and food security in Kibera. https://scholar.archive.org/work/efmvrlk6r5dvbeigfvnuckyrmy/access/wayback/https://edepot.wur.nl/546542

Kwizerimana, S., J. Mugwe and B. Nigat. 2023. Impact of collective marketing participation on farmers' income: Evidence from smallholder avocado farmers of Murang'a County, Kenya. Social Sciences and Humanities Open 8:1.

Larsen, A.F. and H.B. Lilleør. 2014. Beyond the Field: The Impact of Farmer Field Schools on Food Security and Poverty Alleviation. World Development 64:843-859.

Linderhof, V., V. Janssen and T. Achterbosch. 2019. Does agricultural commercialization affect food security: The case of crop-producing households in the regions of Post-Reform Vietnam? Sustainability 11:5-7.

Lupi, V., C. Candelise, M.A. Calull, S.Delvaux, P.Valkering, W. Hubert, A.Sciullo, N. Ivask, E. Van der Waal, I. J. Iturriza, D. Paci, N Della Valle, G. Koukoufikis and T. Dunlop. 2021. A characterization of european collective action initiatives and their role as enablers of citizens' participation in the energy transition. Energies 14:24-28.

Lutomia, C. K., G.A. Obare, I.M. Kariuki, and G. S. Muricho. 2019. Determinants of gender differences in household food security perceptions in the Western and Eastern regions of Kenya. Cogent Food and Agriculture 5:1-7.

Magambo, G., W. Oluoch-kosura, and C. Moraa. 2022. Does the adoption of soil carbon enhancing practices translate to increased farm yields ? A case of maize yield from Western Kenya Heliyon 5:22-25.

Malual, J. D. and R. E. Mazur. 2022. Social capital and food security in post-conflict rural Lira District, northern Uganda. Disasters 46:80-94.

Min-Han Tsai and Yir-Hueih. 2022. Group Heterogeneity and the Economic Effect of Farmer Organisation Participation: Empirical Evidence from Taiwan. Journal of Agricultural Economics 74:473-491.

Mutungi, C., J. Manda, S.Feleke, A. Abass, M. Bekunda, I. Hoschle-Zeledon and G. Fischer. 2023. Adoption and impacts of improved post-harvest technologies on food security and welfare of maize-farming households in Tanzania: a comparative assessment. Food Security 15:1007-1023.

Mwambi, M., J. Bijman and P.Mshenga. 2020. Which type of producer organization is (more) inclusive? Dynamics of farmers' membership and participation in the decision-making process. Annals of Public and Cooperative Economics 91:213-236.

Nakazi, F., P.Aseete, E. Katungi and M. Adrogu Ugen. 2017. The potential and limits of farmers' groups as catalysts

of women leaders. Cogent Economics and Finance 5:1-16.

Niles, M.T., J.Rudnick, M.Lubell, L.Cramer and M. T. Niles. 2021. Household and Community Social Capital Links to Smallholder Food Security 5:1-14.

Njuguna, K.H.N. Isaboke and S.N. Ndirangu. 2022. Determinants of smallholders' choice of avocado marketing outlets and profitability in Murang'a County, Kenya. SN Business and Economics 2:8-15.

Njuki, J., S.Eissler, H.J. Malapit, R.S. Meinzen-Dick, E. Bryan and A.R. Quisumbing. 2021. A review of evidence on gender equality, women's empowerment, and food systems. SSRN Electronic Journal.

Nosratabadi, S., N.Khazami, M. Ben Abdallah, Z. Lackner, S. S.Band, A. Mosavi and C. Mako. 2020. Social Capital Contributions to Food Security: A Comprehensive Literature Review. Foods 11:1-18.

Poole. 2017. Smallholder Agriculture and Market Participation. In Smallholder Agriculture and Market Participation. https://doi.org/10.3362/9781780449401

Quisumbing, A.R., K. Sproule, E.M. Martinez and H. Malapit. 2021. Do tradeoffs among dimensions of women's empowerment and nutrition outcomes exist? Evidence from six countries in Africa and Asia. Food Policy 100:102001.

Ragasa, C., N.L. Aberman and C. Alvarez Mingote. 2019. Does providing agricultural and nutrition information to both men and women improve household food security? Evidence from Malawi. Global Food Security 18:45-59.

Republic of Kenya, Ministry of Industry, Trade and Co-operative. 2019. Government of Kenya Ministry of Industry, Trade and Co-Operatives Co-Operative Policy Promoting Co-operative Societies for Industrialization. https://repository.kippra.or.ke/handle/123456789/2990

Shumeta, Z. and M.D'Haese. 2018. Do Coffee Farmers Benefit in Food Security from Participating in Coffee Cooperatives? Evidence from Southwest Ethiopia Coffee Cooperatives. Food and Nutrition Bulletin 39:266-280.

Sraboni, E. and A. Quisumbing. 2018. Women's empowerment in agriculture and dietary quality across the life course: Evidence from Bangladesh. Food Policy 81:21-36.

Sseguya, H., R. E.Mazur and C. B.Flora, 2018. Social capital dimensions in household food security interventions: Implications for rural Uganda. Agriculture and Human Values 35:117-129.

Valujeva, K., E.K. Freed, A.Nipers, J.Jauhiainen and R.P.O. Schulte. 2023. Pathways for governance opportunities: Social network analysis to create targeted and effective policies for agricultural and environmental development. Journal of Environmental Management 325:116563.

Waha, K., M. T.Van Wijk, S.Fritz, L. See, P. K. Thornton, J. Wichern and M. Herrero. 2018. Agricultural diversification as an important strategy for achieving food security in Africa. Global Change Biology 24:3390-3400.

Wegi, B., J. Haji and A.Mirzabaev. 2023. Determinants of food and nutrition security : Evidence from crop-livestock mixed farming households of Central and Eastern Ethiopia. Journal of Agriculture and Food Research 12:100556.

Woldu, T., F.Tadesse and M.K.Waller. 2018. Women ' s participation in agricultural cooperatives in Ethiopia Women's Participation in Agricultural Cooperatives in Ethiopia. International Association of Agricultural Economists (IAAE) 2015 Conference 8:9-14.

World Food Programme. 2015. Consolidated Approach to Reporting Indicators of Food Security (CARI) Guidelines, Food security analysis (VAM). November.

Zou, Y. and Q. Wang. 2022. Impacts of farmer cooperative membership on household income and inequality: Evidence from a household survey in China. Agricultural and Food Economics 10:1-8.