Extended Abstract
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Paper Title	**Characterising diversity of rural farm households in Eastern Africa: implications for food security and intra-household decision-making**

Abstract prepared for presentation at the 98th Annual Conference of The Agricultural Economics Society will be held at The University of Edinburgh, UK, 18th - 20th March 2024.

Abstract	***200 words max***

The heterogeneity in East African small-holder agricultural systems influences the farm households' welfare outcomes. A range of characteristics determine the variance between farming systems and a key pathway for intervention is intra-household decision-making.
This study aims to capture the heterogeneity of rural farm households in Eastern Africa. By doing so we can analyse the influence of such diversity on household food security and how these relate to intra-household decision-making dynamics.
Using data from the Rural Household Multi-Indicator Survey (RHoMIS) 1,199 households in Ethiopia, Kenya, Malawi and Uganda were typologized using partition-based cluster analysis. These were grouped into relatively homogenous classes reflecting their socio-demographic characteristics, resource endowment and farm orientation based at a country level to reflect the unique institutional conditions within these countries. Additional chi-square analysis was then used to characterise the differences in food insecurity and intra-household decision-making of these clusters.
Five distinct farm household clusters were identified in Ethiopia and Kenya, four in Malawi and three in Uganda. The typologies reveal considerable diversity in the structural and functional characteristics of smallholder farmers. In Kenya and Uganda, clusters with high off-farm income were more food secure, while in Ethiopia and Malawi off-farm income share varied little between clusters. In Ethiopia, Kenya and Uganda, women had greater decision-making control in clusters comprising least educated household heads. Female decision-making control was negatively associated with the resource endowment of clusters in Kenya, Malawi and Uganda. In Malawi, prominent female decision-making power was associated with high off-farm income clusters, while the reverse was found for Ethiopia, Kenya and Uganda.
The results of this study emphasise the importance of understanding rural farm household heterogeneity and can aid design of tailored interventions to target household food insecurity and gender inequity in decision-making in Eastern Africa.

Keywords	Small-Holder Farm Typologies; East African Agricultural Systems; Cluster Analysis
JEL Code	C12; Q12

Introduction	***100 – 250 words***

Eastern African farming systems are dominated by smallholders, who account for approximately 75% of all agricultural production (Salami *et al.*, 2010). These smallholders traditionally practise mixed farming, cultivating small areas of food crops and are highly heterogenous in socio-economic conditions, ecological environments, livelihood strategies, and production objectives. These have been found to have strong conditioning effects on farm households' welfare and food security (Babulo *et al.*, 2008; Vanlauwe *et al.*, 2014; Gebre and Rahut, 2021). Studies are increasingly acknowledging a positive association between household food security and women's decision-making control over income,

resources and production (Okonya *et al.*, 2021; Lufuke *et al.*, 2023). While these studies are increasingly incorporating indicators of household food security into their typologies (Kuivanen *et al.*, 2016; Nabuuma *et al.*, 2021; Ulukan *et al.*, 2022), few have included intra-household gender dynamics and indicators of female decision-making.
This paper adds to the nascent literature on small-holder typologies and assess the heterogeneity of households across Ethiopia, Kenya, Malawi and Uganda. We employ a rich dataset, the RhoMIS database, which covers a range of countries and agro-ecosystems in the Global South and we add to previous analysis of these data by comparing the heterogeneity of these typologies found against intra-household decision making dynamics and associated food security strategies. Moreover, using a data driven approach we derive our typologies at country level, recognising the diversity of institutional structures that define accessibility and gender dynamics across the countries.

Methodology

100 – 250 words

Data for the analysis were sourced from recent cross-sectional farm household characterisation surveys collected using the Rural Household Multi-Indicator Survey (RHoMIS) tool, available at the Harvard Dataverse RHoMIS data repository (RHoMIS, 2019).From the pool of information collected by RHoMIS, nine variables describing household-level sociodemographic characteristics, resource endowment and farm orientation were selected for constructing the farm household typologies. To analyse the relationship between the typologies, household food security status and gendered decision-making dynamics, one household-level food security indicator and one female decision-making indicator were included in the typology construction. The information underpinning these indicators is described in detail below.

Table 1. Characteristics of rural farming households in Ethiopia (*n* = 270), Kenya (*n* = 430), Malawi (*n* = 177) and Uganda (*n* = 322).

Characteristic	Ethiopia	Kenya	Malawi	Uganda	χ^2	P-value
Sociodemographic characteristics						
Head age (years)	39.50 (16.00)^{ab}	46.00 (22.00)^{ac}	40.00 (21.00)^{c}	44.00 (14.00)^{b}	40.63	0.000
Household size (number of persons)	6.00 (3.00)^{a}	4.00 (3.00)^{a}	5.00 (2.00)^{a}	6.00 (4.00)^{a}	104.99	0.000
Head education (%)					209.85	0.000
No school	38.89	6.98	7.34	10.25		
Primary	46.30	48.14	66.10	54.66		
Secondary	11.48	34.65	25.99	31.99		
Tertiary	3.33	10.23	0.56	3.11		
Resource endowment						
Land cultivated (ha)	1.00 (1.50)^{ab}	0.60 (0.80)^{ac}	0.80 (0.80)^{bd}	1.20 (0.80)^{cd}	111.04	0.000
Livestock holding (TLU)	2.80 (2.97)^{ab}	1.48 (2.00)^{a}	0.15 (0.69)^{ab}	1.29 (1.85)^{b}	259.27	0.000
Farm orientation						
Off farm income (0-1)	0.00 (0.00)^{a}	0.00 (0.50)^{a}	0.20 (0.70)^{a}	0.10 (0.20)^{a}	116.11	0.000
Market orientaiton (0-1)	0.58 (0.52)^{ab}	0.53 (0.51)^{a}	0.40 (0.52)^{bc}	0.58 (0.38)^{c}	24.73	0.000
Livestock orientation (0-1)	0.08 (0.42)^{a}	0.44 (0.78)^{ab}	0.07 (0.22)^{b}	0.22 (0.48)^{ab}	92.71	0.000
Crop diversity (count)	1.00 (1.00)^{a}	2.00 (1.00)^{ab}	1.00 (1.00)^{b}	4.00 (1.00)^{ab}	538.18	0.000
Food security indicator						
FIES Score (0-8)	5.00 (3.00)	3.00 (6.75)	7.00 (3.00)	2.00 (4.00)	449.53	0.000
Female decision-making indicator						
Female control (0-1)	0.50 (0.00)^{ab}	0.50 (0.38)^{cd}	0.50 (0.34)^{ac}	0.56 (0.53)^{bd}	56.33	0.000

^{abcd} Within a row, values with the same superscript letters are significantly different a $p < 0.05$ level (*post hoc* Mann-Whitney U test); Medians are presented with inter-quartile range in brackets, with the exception of head education where percentages are given.

The PAM method, based on the Gower distance, was selected for clustering, due to its greater robustness to outliers than other partition-based algorithms (Jin and Han, 2010) and ability to cluster mixed data types. The Gower distance measures the dissimilarity between two observations with mixed numeric and non-numeric elements, generating a distance matrix. The PAM algorithm was then applied to the Gower distance matrix to map observations into a predetermined number of clusters (*k*) (Botyarov and Miller, 2022). The Silhouette Width method was used to determine the optimal number of clusters for each country (Sai Krishna *et al.*, 2018). The method computed an average silhouette coefficient of observations for different values of *k.* The coefficient takes a value between -1 and 1 and is an aggregated measure of how close observations in one cluster are to observations in neighbouring clusters, representing the separation distance between clusters (Kassambara, 2017).

Results

100 – 250 words

From the cluster analysis, it emerged that rural farming households within the study sites could be grouped into farm clusters that reflected their structural and functional diversity, as well as their heterogeneity in household food security status and gendered decision-making dynamics. For each country, the Silhouette Width was computed for two to ten clusters and revealed the optimal number of farm clusters were five for Ethiopia, five for Kenya, four for Malawi and three for Uganda. The average silhouette coefficients for the typologies were 0.44 for Ethiopia, 0.43 for Kenya, 0.44 for Malawi, and 0.55 for Uganda, indicating the households are well clustered in each country.

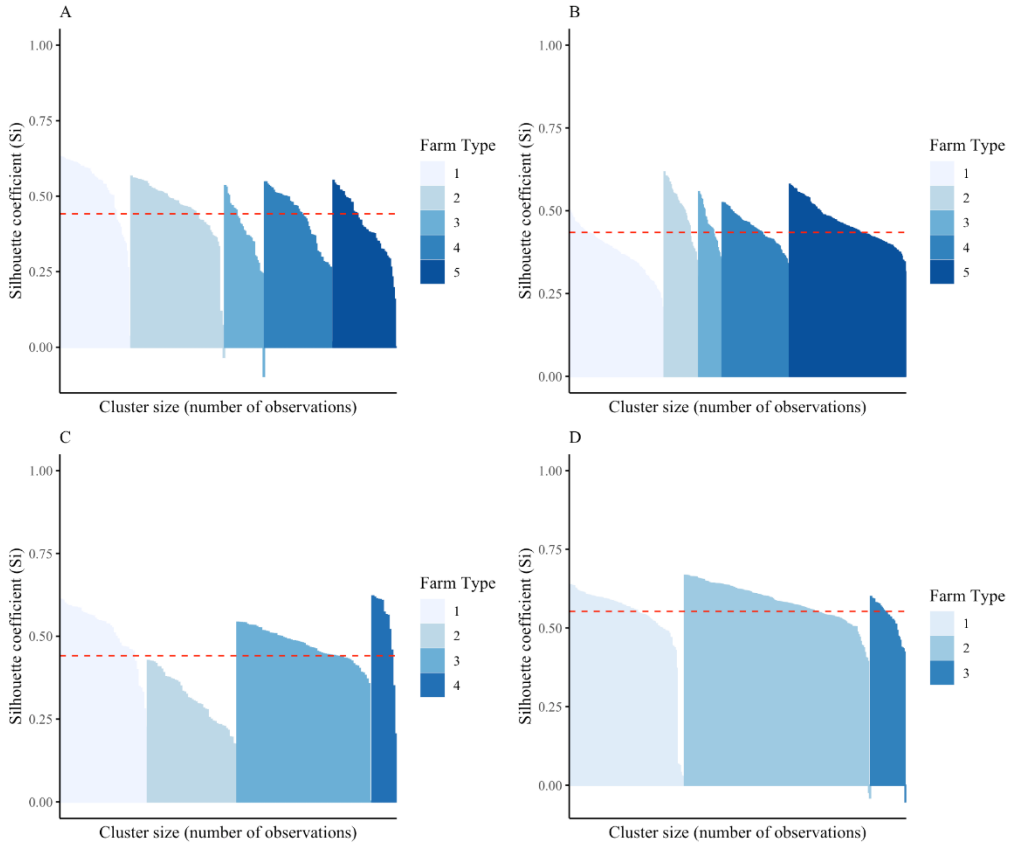

Figure 1. Silhouette plot of silhouette coefficients of farm clusters

Household food security status of farm clusters

Pearson's chi-squared tests revealed statistically significant associations between farm clusters and FIES scores in Kenya (χ^2 (NA, N = 430) = 64.64, $p < 0.01$) and Uganda (χ^2 (NA, N = 322) = 28.57, $p < 0.05$). Although the association between farm clusters and FIES scores in Ethiopia and Malawi were not considered statistically significant, visual comparison of mean FIES scores revealed nuances in the food security status of the farm clusters. For Kenya, farm clusters 2 and 5 were considered food secure, with Cluster 2 reporting the lowest mean FIES score. For Ethiopia, farm clusters 2 and 3 were conceived as food secure and reported similar mean FIES scores of 3.77 and 3.75, respectively. For Uganda, all farm clusters were conceived as food secure, with mean FIES scores ranging between 2.13 and 3.76 months. Specifically, Cluster 1 reported the lowest mean FIES score, while Cluster 3 reported the highest mean FIES score.

Intra-household decision-making dynamics of farm clusters

Kruskal-Wallis tests revealed significant differences in intra-household decision-making dynamics, measured as female control, of farm clusters in Ethiopia (χ^2 (4) = 9.50, $p < 0.05$), Kenya (χ^2 (4) = 38.75, $p < 0.001$), Malawi (χ^2 (3) = 10.74, $p < 0.05$) and Uganda (χ^2 (2) = 13.60, $p < 0.01$).

Discussion and Conclusion

100 – 250 words

Employing a data-driven approach identifies distinct clusters of farm households and some of the non-linear relationships between food security, gender dynamics and resource endowments. The most salient factors distinguishing the farm clusters are educational attainment of the household head, levels of resource endowment, market orientation and livelihood diversification through off-farm income. We found female decision-making control is high across Uganda's food secure farm clusters; corroborating the consensus in the literature that women's empowerment in decision-making and control over income supports increases in household nutrition and food security (Essilfie *et al.*, 2021; Kilimani *et al.*, 2022; Lufuke *et al.*, 2023).

Rural farm households in Eastern Africa are highly heterogenous. Understanding this diversity is critical for the design and implementation of agricultural development policies and interventions that are tailored to local contexts. The typologies reveal considerable diversity in the structural and functional characteristics of rural smallholder farmers, as well as their food security status and intra-household decision-making dynamics. Additionally, variations in the way in which farm clusters form between countries reflect local institutional factors and the socio-political contexts of the countries and this should be recognised in future studies going forward. For instance, interventions that challenge the structural barriers women face in agriculture are crucial for improving food security outcomes in Ethiopia, Kenya and Malawi, and among low-resource endowed clusters where women's decision-making power is prominent. Additionally, it is critical that gender mainstreaming is at the forefront of these tailored approaches, to ensure interventions that improve food security, through for example promoting off-farm income earning opportunities or access to education, do not foster gender disparities in the household and disenfranchise women's decision-making power.