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The social and economic diversity of the coffee-banana farming system and technology uptake in Central Uganda

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ABSTRACT

Food systems of the future that will guarantee food and nutrition security of millions of poor farming households will have to be both economically and socially diverse. Diversity of farming systems acts as a catalyst for innovation, commercialisation as well as technology adoption. This study sought to find farm typologies and explore the social, enterprise and economic diversity of the various farm types based on a promoted Growing Bananas with Trees and Livestock (GBTL) technology system that was implemented by National Agricultural Research Organisation and Bioversity International in three districts of Central Uganda, Kiboga, Nakaseke and Ssembabule. Using Principal Component Analysis (PCA) and Cluster Analysis (CA), typologies were created in which two distinct clusters of farming households were revealed. Further analysis of the clusters through Food Consumption Scores, food classes, and other descriptive statistics indicated that the two clusters were socially and economically diverse. Findings indicated that Cluster 1 is made up of smaller farms with high crop diversity. Families in Cluster 1 sell more of their produce and subsequently have lower food security compared to the land-abundant, off-farm earning and more food secure Cluster 2. We failed to reject the hypothesis that socially and economically diverse farmers adopt technologies more given that the level of GBTL adoption was about 25% and about 70% for Banana + Goats within both clusters.

Keywords: Enterprise diversity; Food security; Farm typologies; Uganda

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Introduction

Livelihood diversity is a strategy for survival of millions of farm households living in the countryside of developing countries. There is a strong nexus linking diversification of farming systems with poverty reduction, increased farm productivity and natural resource management (Ellis, 1999). Although debates on sustainability of agricultural systems often overlook social and sometimes economic dimensions, these have a far-reaching effect on uptake of technologies that later generate social and economic benefits for farm households (Bacon et al., 2012). Diversified farming systems are defined as farming practices and landscapes that intentionally include functional biodiversity at multiple spatial and/or temporal scales in order to maintain ecosystem services that provide critical inputs to agriculture, such as soil fertility, pest and disease control, water use efficiency, and pollination as well as food and other household needs (Kremen et al.,2012).

Agricultural technologies are seen as an important route out of poverty for millions of poor people in developing countries. However, the rate of spread of these technologies has remained low in most of these countries. A range of factors such as technological, economic, institutional and human specific factors have been found to be key determinants of adoption (Mwangi & Kariuki, 2015). The variability and diversity of adoption among farm households attributed to differences in socio-economic characteristics have also been documented for years to pose challenges for extensionists, researchers, governments and development partners on how to promote widespread uptake of technologies for creation of lasting poverty reduction and food security increase (Solano et al., 2000; Somda et al., 2005; Thomas et al., 2017).

In addition, diverse farming systems in many developing countries, including the humid tropics, are found across a wide range of cultures and landscapes. The biophysical, institutional, social and economic drivers differ between contexts, resulting in different responses from farm households and communities which are often at different development stages with different skills sets and ambitions across the agro-ecosystems (Bacon et al., 2012; Galdeano-Gómez et al., 2016). Over time, these differences in drivers and farm features lead to temporal and spatial variability between and within farming systems. The existing farming systems variability is challenging to fully comprehend, leading to partial and incomplete representation of reality in research and development programs (Alvarez et al, 2014).

The future of farming systems will depend on their ability to sustainably produce enough food to feed about 10 billion people by 2050 in the face of increasing climate change (Kremen et al., 2012; Childers et al., 2011). Globally, the Green Revolution led to expansion of monocultures by about 80% in Asia on areas under rice, 90% in Latin America on areas under wheat and doubled the world's irrigated cropland (Tilman et al., 2001; Evenson & Gollin, 2003). Smallholder farms (<2ha) have however persisted alongside the expansion of large-scale agriculture making up over 85% of the global food producers supplying supply 50% of the worlds' cereal, 60% of the world's meat and 75% of the world's dairy production (Herrero et al.,2010). It is also estimated that 50% of the world smallholders utilize resource-conserving farming methods including diversification (Altieri & Toledo, 2011). Although new crop varieties released between the 1960s and 1990s under the Green Revolution have spread to cover over 80% of land area in Asia, Sub Saharan Africa only covered about 40% of its land with these varieties (Evenson & Gollin, 2003), indicating persistence of traditional farming systems.

Coffee, grown in many parts of Uganda, is an important source of household income. Up to 88% of farmers intercrop coffee with banana and other annual crops integrated with livestock for simultaneous generation of cash and food as well as mulching material, shade and manure

(Bongers et al., 2012, Mpiira et al 2013). This diversification of the farming system comes with economic gains in terms of higher coffee yields and stability of household food security (van Asten et al., 2011). However, at the household level in Uganda many new technologies with great potential have not been taken up, partly because they do not blend in well with the heterogeneous smallholder systems, which require specific technological interventions (Evenson & Gollin, 2003; Abay et al., 2016), they yield low returns (Bold et al., 2015) or farmers are too capital constrained to afford them (Sserunkuuma, 2005). These specific differences amongst the farming households in the rural areas may influence farm household's acceptance and adoption of the introduced technologies which aim at improving farm production, productivity, natural resource management hence improved livelihoods (Lal et al. 2001; Emtage and Suh 2005).

This study was undertaken to identify the predominant farm typologies of farming households within the banana farming system in central Uganda who participated in the validation of Growing of Bananas, Trees and Livestock Technology (GBTL) overseen by Bioversity International in partnership with the National Agriculture Research Organisation through the National Banana Research Programme in 2015. The study sought to answer two questions: 1) how diverse are the banana farms in central Uganda and 2) what was the effect of farm household diversity on the ongoing use of GBTL technology during the post-project period.

Farm diversity classification

The construction of typologies to aid the design and delivery of natural and rural development is increasing in popularity due to their potential to aid the description and interpretation of diversity in rural households (Emtage, 2004). Developing a typology constitutes an essential step in any realistic evaluation of the constraints and opportunities that exist within farm households (Timothy, 1994). Typology studies can therefore be of great importance for exploring the factors that explain the adoption of new technology (Kostrowicki, 1977; Mahapatra and Mitchell, 2001).

Many farm system typologies have been developed globally following on a number of criteria. The main classification criteria used have been the main crop produced (Andersen et al., 2007; Dossa et al., 2011; Zorom et al., 2013). Others have used production systems (Hernández-Martínez et al., 2009) or input types used and intensification levels (Sebatta et al., 2019). Other studies that have attempted to consider farm household diversity have focused on differences in resource endowments and crop management (Righi et al., 2011; Tittonell et al., 2010; Bongers et al., 2015).

This study builds on the previous studies that have classified coffee-banana farms in Uganda by incorporating social, economic and livestock variables to understand the diversity of farms in central Uganda.

Methodology

Study area

This study was conducted in three districts of central Uganda namely, Kiboga, Ssembabule and Nakaseke. The common feature among the three districts is that they are naturally divided into two geographical areas that respectively support pastoral and crop farming in what is known as the Masaka-Mbarara cattle corridor. The farm sizes in these areas have declined, the area under annual cropping has increased, grazing lands have been converted to agriculture and production has become increasingly market-oriented. Soil fertility, particularly for poor-resource households, has been declining due to more continuous cropping, smaller farms and off-farm crop sales resulting in nutrient mining.

Sampling

Participants in the study were from sites where the Growing of Bananas, Trees and Livestock Technology (GBTL) was implemented. A total of 247 respondents were interviewed across the three sites. Of the sampled farmers, 74 were primary beneficiaries and 173 were secondary beneficiaries. Primary beneficiaries were those initial selected farmers under the farmer experimentation group that received bananas, goats and fodder trees under the project. Secondary beneficiaries were farmers within the community that picked interest and received bananas, kids and fodder shrubs from the primary beneficiaries during the course of the project implementation. Typically in banana-growing regions, some households have a few goats which are tethered each day by road sides or fallowed fields. The GBTL technology aims to increase on-farm manure production for bananas with a technology within reach of more resource-poor farm households. Goats are zero-grazed in a raised floor shelter facilitating manure collection, Shrub legumes planted on field borders or contours are plucked every day. Farm households learn both to calculate total fodder intake based on goat size and performance and to balance the protein-rich legumes with energy feeds like banana skins, sweet potato vines and other pruned vegetation. Resources for technology implementation and expansion, including seed, building materials for the raised floor structure, fodder and crop by-products are widely available within the rural community.

The interviews were conducted using pre-tested and semi-structured questionnaires among 74 primary and 173 secondary beneficiaries. Over the project life, primary farm households in the villages tested the technology and secondary beneficiaries learned about the technology from primary households. The respondents had benefited directly or indirectly from project inputs such as fodder shrub planting material, pregnant goats and kids produced from the goats given as well as training sessions during two years to fine-tune and adapt technologies by household.

Primary data were collected on variables such as labour, land, education, household composition, livestock, crop resources, tree resources, access to information, access to extension services, education level of the spouses and absolute income. Data collected were entered in SPSS, after which analysis was done using R to generate clusters and statistical analysis done in Stata.

Data analysis

Farm typologies

This study employed a multivariate approach for identification and characterisation of farm household types. Using R and Stata 14.0 software, both univariate descriptive statistics and multivariate statistical techniques were used for the analysis of data. Multivariate statistical techniques have been widely used for farm typology and characterization studies (Kobrich et al., 2003; Andersen et al., 2009; Guto et al., 2010). Factor analysis was also used to reduce the number of variables and cluster analysis to identify typical farm households under study.

Multivariate statistical techniques such as Principal Component Analysis (PCA) and Cluster Analysis (CA) are suitable tools for identifying important socio-economic characteristics of typical farm households that underlie the uptake of a new technology. Differentiation of typical farms helps in the construction of mathematical programming models on the basis of typical farm households (Bidogeza et al., 2009).This study hence, used both principal component analysis (PCA) and cluster analysis (CA) to identify farm household typologies following Ding and He (2004), Jolliffe (2002), Kobrich et al.(2003) and Abdi (2007). We used both socio-economic variables and income from different household and enterprise activities in the PCA. Since the impact of off-farm income on technology adoption is well-reported (Savadogo et al. 1998; Nehring et al. 2005; Fernandez-Cornejo et al. 2005), the study also used off-farm income as a factor for farm classification.

Factors were identified using orthogonal rotation (varimax method as in Kaiser 1970; Gorsuch

1983) so that a smaller number of highly-correlated variables might be put under each factor, facilitating interpretation (Field 2005). In accordance with Kaiser's criterion, all factors exceeding an eigenvalue of one were retained (Kaiser 1970). Kaiser's criterion is accurate when the number of variables is less than 30 (Field 2005), which was the case for our data set. The sampled farms were clustered based on the five principal components identified by PCA following Anderberg (1973).

To determine the number of clusters two steps were followed – the hierarchical method and K-means clustering method. For hierarchical clustering, Euclidian distance and Ward's computation method were considered. The number of clusters retained from Ward's method (four in our study) was used as starting values in the K-means method. Accordingly, the number of clusters that seemed most realistic and meaningful was chosen for the final solution.

Ward's method resulted in a range of cluster solutions, where each observation started out as its own cluster and was successively joined by similar clusters until only a single cluster remained (Reynolds et al, 2006) This agglomerative nesting process was represented by a dendrogram. In determining the optimal cluster cut-off points, a trade-off was sought between the number of clusters and the level of dis-similarity within clusters, with the objective of maximizing both intra-cluster homogeneity and inter-cluster heterogeneity (Hair et al, 2010).

Social diversity and food security analysis

Social diversity was analysed using descriptive statistics on social indicator variables in farming and non-farm activity. The four social indicator questions were: 1) what guides decisions in a household, and how does the opinion of others in the household or community influence one's decisions in farming and how independent are household decision makers when 2) deciding on what to grow, 3) how and where to market produce and 4) whether to work in non-farm activities. We further explored the gender dimension of decision making and social diversity by comparing the social indicators across three different household types by household head; both adult male and female present, adult female only and adult male only.

Food security in this study was calculated using a Food Consumption Score (FCS) by first grouping all the foods that the household had consumed in the last 7 days into eight broad categories (FAO/WFP, 2008; WFP, 2015; FAO, 2018). These categories were; starch (tubers and cereals), vegetables (dark green, leafy and other vegetables), fruits, meat (eggs, fish, fresh and organ meat), legumes, dairy (milk and its products), oil and sugar. The frequency of consumption of the foods was also used to calculate the final FCS. These we multiplied by a weight with starches multiplied by 2, vegetables by 1, fruits by 1, meats by 4, legumes by 3, milk by 4, oils by 0.5 and sugar by 0.5. The expected maximum score was 112 if a household consumed all these foods daily in the last 7 days. The household score was then compared with World Food Programme (WFP) pre-established thresholds that indicate the status of the household's food consumption as Poor food consumption at FCS between 0 and 21, Borderline food consumption at FCS between 21.5 and 35, and Acceptable food consumption at FCS > 35.

Results

In this section we present the results from the Principal Component Analysis (PCA), Cluster Analysis (CA) and descriptive analyses. The factor map in Figure 1 shows that land ownership (Landown) was highly correlated with land area (Landarea), Tropical Livestock Units (TLU) and incomes from banana. Results also indicated that the higher the banana income the lower the off-farm income earned from sale of labour. Household labour cost was found to increase with increasing banana incomes. Figure 1 also shows a factor map from the cluster analysis. It indicates that the individual plots are skewed to the left generating three clusters. However, Figure 2 indicates two large clusters in the dendrogram with a very small cluster of only two sample units. Hence, the subsequent analysis was based on the two well-structured clusters.

Results indicated that generally sampled households derived much of their livelihood through farming and marketing of coffee, banana and goats given that they earned more from that activity. However, off-farm activities also contributed a sizeable amount of income to the farm household portfolio (Table 1). A closer look at the landholdings accessed and owned reveal that these are smallholder farmers accessing less than 2ha. Cluster 2 farm households seem slightly more land-abundant than Cluster 1 farms and they earn more from off-farm activities and banana production than from coffee and goats (Table 1).

Figure 1: Quantitative variable FAMD (Top) and factor map (Bottom)

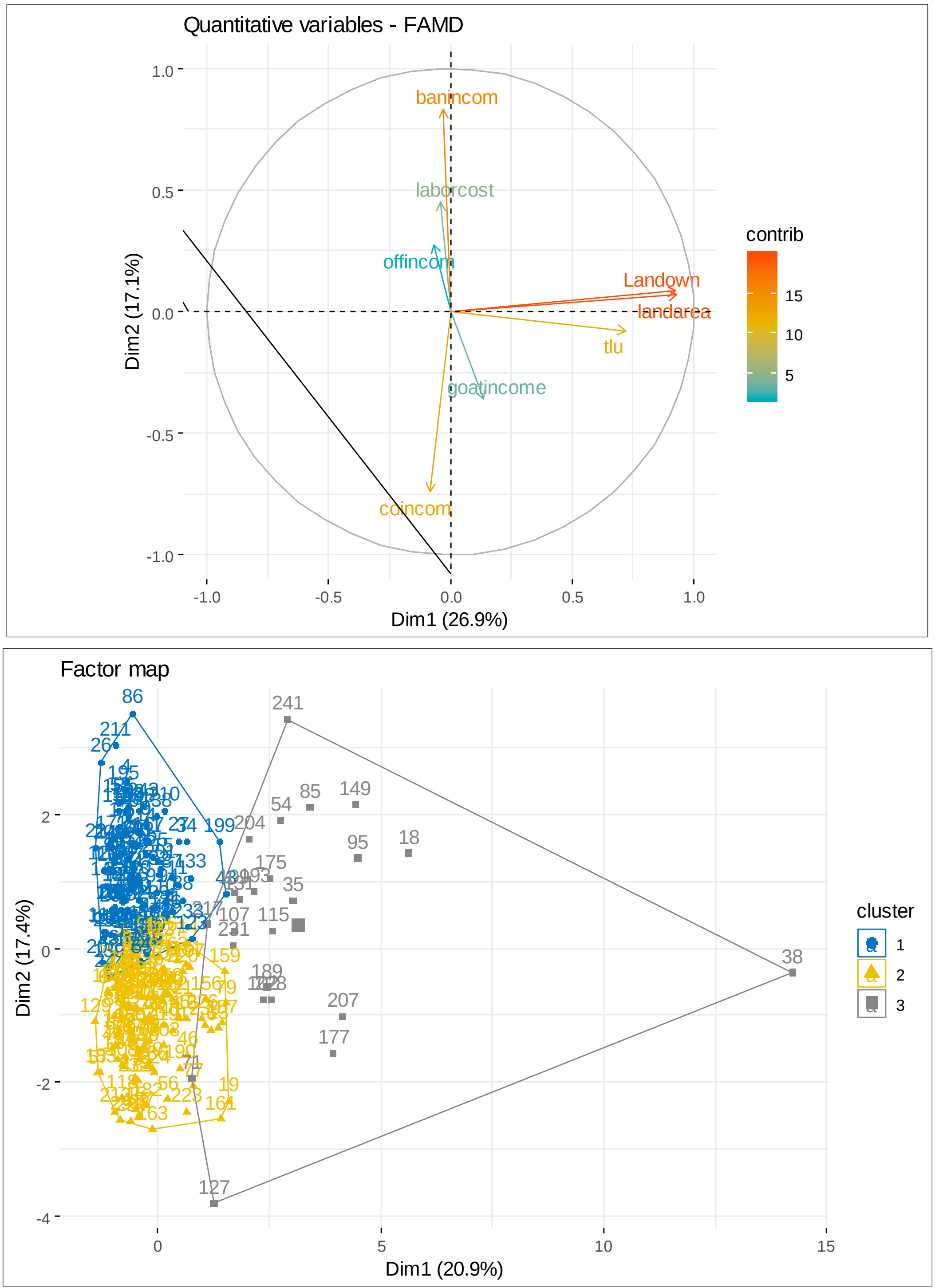


Figure 2: Dendrogram resulting from Ward's method of Cluster Analysis.

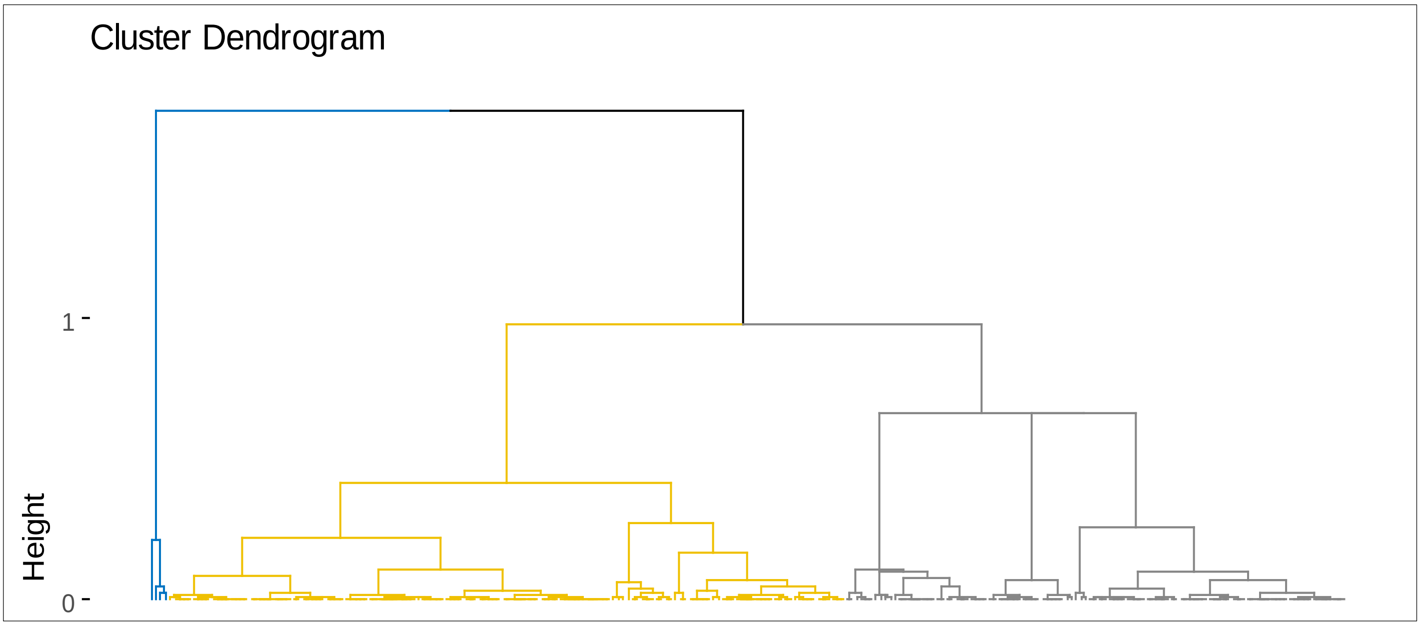


Table 1: Summary statistics for the variables used in PCA and Cluster analysis

Variable	Pooled sample		Cluster 1		Cluster 2*	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Household size	4.8	1.9	4.5	2.1	5.0	1.7
Tropical Livestock Units	1.7	2.3	1.7	2.1	1.7	2.5
Off-farm income (Million UGX)	39.63	38.49	31.39	36.63	46.80	38.78
Coffee income (proportion of the family income contribution)	31.0	24.0	46.0	25.0	17.9	12.7
Banana income (proportion of the family income contribution)	43.0	28.1	20.1	14.9	62.9	20.8
Goat income (proportion of the family income contribution)	19.0	15.2	24.2	18.6	14.5	9.3
Total land area accessed(ha)	1.78	1.48	1.61	1.02	1.93	1.78
Land owned(ha)	1.66	1.54	1.45	1.08	1.85	1.84
Labour cost (million UGX)	1.671	2.290	1.687	2.084	1.658	2.463

**Cluster 2 comprises 56.59% of the sampled households*

Although Cluster 2 farm households access on average more land than Cluster 1, they earn 47% of their estimated annual income from off-farm activities compared to 31% for Cluster 1. Conversely, Cluster 1 farms earn about 46% of their annual income from coffee sales compared to 18% earned by Cluster 2 farming households (Table 4). Goat farming was tested among all sampled households recently. However, the two clusters show different proportions of earnings from goats. Cluster 1 earned 24% of their income from goat sales compared to 15% earned by Cluster 2 (Table 2). Distance to the district capital reveals that Cluster 1 farming households are nearer the closest urban centres than Cluster 2 households by about 3 kilometres, making the latter more rural.

Table 2:Farm household type characteristics by cluster

	Clusters					
	Pooled sample(n=247)		Cluster1(n=115)		Cluster 2 (n=132)	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Food insecurity score	1.664***	0.612	1.555	0.534	1.760	0.661
% of fertilizer cost of total input cost	5.354	13.304	3.899	9.627	6.622	15.755
Proportion of female labour cost in banana	0.163**	0.219	0.126	0.205	0.195	0.227
% of total annual income from off farm	39.628***	38.492	31.391	36.626	46.804	38.775
% of coffee income of all agricultural income	31.002***	23.957	46.018	25.043	17.921	12.714
% of banana income of all agricultural income	42.954***	28.094	20.085	14.855	62.877	20.760
%age of fodder income/benefits of all agricultural income	6.485	9.245	5.065	8.904	7.523	6.485
% of goat income of all agricultural income	19.038***	15.176	24.216	18.615	14.527	9.322
%age of annual income from agricultural production	80.555	31.026	77.666	33.050	83.072	29.041
Total agricultural land accessed (ha)	1.781*	1.480	1.605	1.017	1.934	1.779
% of agricultural land of all accessible land	97.792	3.886	97.361	5.155	98.168	2.218
Land owned (ha)	1.662**	1.544	1.451	1.078	1.846	1.842
Percentage of fees in total household expenditure	24.299	17.409	25.281	17.703	23.442	17.171
Tropical Livestock Units (TLUs)	1.671	2.290	1.687	2.084	1.658	2.463
Number of dependents	3.696	2.103	3.887	2.188	3.530	2.021
Number of house rooms	3.636**	1.369	3.443	1.237	3.803	1.459
Distance to the nearest banana and goat market (km)	3.420	0.641	3.475	0.412	3.371	0.786
Distance to the nearest all weather road (km)	3.195	3.180	3.224	3.379	3.170	3.009
Distance to the nearest district capital (km)	10.865*	12.643	9.461	12.103	12.088	13.018
Age of household head	44.628**	14.697	42.409	14.405	46.561	14.730
Education level of household head (years in formal school)	7.065	3.562	6.800	3.343	7.295	3.739
Total farm labour cost (million Uganda Shillings)	0.744***	0.789	0.510	0.664	0.981	0.836
Current Value of livestock owned (million Uganda Shillings)	0.614*	0.734	0.706	0.773	0.536	0.693
Total annual Non-farm Income (million Uganda Shillings)	1.680**	1.950	1.380	1.920	1.950	1.940
Total annual agriculture Income (million Uganda Shillings)	1.112	1.196	1.223	1.232	1.008	1.158

Significance: ***1%, **5% & *10%

Farm enterprise diversity

The most common farm enterprises among the study sample were bananas, maize, cassava, beans, sweet potatoes, coffee, fruits, vegetables, peas, ground nuts, goats and fodder. About 90% of the farm households in Cluster 1 mainly grew bananas, cassava, maize and beans while about 85% of households in Cluster 2 grew these crops. In terms of crop diversity, Cluster 1 households had a more diverse group of crops grown compared to Cluster 2 (Table 3). Several enterprise mixes were identified including Banana + Coffee, Banana + Coffee +Legumes, Banana + Goats +fodder (Growing bananas with trees and livestock GBTL). Only about 30% of the sample constituted primary beneficiaries that received the first batch of goats and the 70%, secondary beneficiaries received kids from the primary beneficiaries. Cluster 1 had a higher proportion of its beneficiaries being primary (38%) than cluster 2.

A higher percentage of Cluster 2 households included goat raising into their farming system than Cluster 1 households, possibly due to a greater level of household wealth. This typology segregation in terms of enterprises adopted is also observed when selecting enterprise mixes. A higher percentage of Cluster 2 than Cluster1 households managed the Banana + Goats and Banana + Coffee mixes. Results revealed almost equal percentages (25%) of farms from both clusters adopting the Banana + Goats +fodder (GBTL) technology that was promoted by the project under study.

Findings also revealed significant differences between clusters regarding energy sources used for cooking. Cluster 1 farm households seemed to use a mixture of firewood and charcoal while Cluster 2 households are heavily dependent on firewood (Table 3).

Table 3: Farm enterprise diversity by cluster

Enterprise	Percentage of farms by cluster			
	Pooled sample (n=247)	**Cluster 1 (n=115)**	**Cluster 2 (n=132)**	**Chi 2 (p-value)**
Bananas	92.31	95.65	89.39	3.390(0.066)
Maize	89.07	93.91	84.85	5.187(0.023)
Cassava	85.02	90.43	80.3	4.954(0.026)
Beans	89.07	92.17	86.36	2.131(0.144)
Sweet potatoes	57.09	57.39	56.82	0.008(0.928)
Coffee	19.43	18.26	20.45	0.189(0.664)
Fruits & vegetables	58.24	64.86	53.7	0.001(0.979)
Legumes (beans + peas +groundnuts)	92.00	88.24	100	1.023(0.312)
Goats	69.64	66.96	71.97	0.731(0.393)
Fodder	24.7	24.35	25.00	0.014(0.906)
Key enterprise mixes				
Banana + Coffee	18.22	16.52	19.7	0.414(0.515)
Banana + Coffee +Legumes	15.79	15.65	15.91	0.003(0.956)
Banana + Goats	70.61	68.18	72.88	0.604(0.436)
Banana + Fodder	25.00	25.45	24.58	0.023(0.878)
Banana + Goats +fodder (GBTL)	25.10	25.00	25.20	0.001(0.972)
GBTL primary beneficiaries	29.96	38.26	22.73	
GBTL secondary beneficiaries	70.04	61.74	77.27	7.067(0.008)
Energy type used for cooking				
Biogas	2.02	2.61	1.52	6.215(0.045)
Charcoal	8.50	13.04	4.55	
Firewood	89.47	84.35	93.94	

Results indicated that primary beneficiaries significantly adopted more of banana + Goats +fodder (GBTL) and Banana + Fodder combinations while more secondary beneficiaries (68%) concentrated on the Banana + Goats combination (Table 4).

Table 4: Farm mix diversity by beneficiary category

	Percentage of farms by beneficiary category		
Technology combination	**Secondary**	**Primary**	**Chi²**
Banana + Goats	67.63	59.46	Pearson chi2(1) = 1.525 Pr = 0.217
Banana + Fodder	19.65	31.08	Pearson chi2(1) = 3.813 Pr = 0.051
Banana + Goats +fodder (GBTL)	17.92	31.08	Pearson chi2(1) = 5.256 Pr = 0.022

Food availability and food security

Results indicated that Cluster 2 had majority (65.9%) of the farm households in the acceptable food consumption category compared to Cluster 1 (41.74%). Relatedly, Cluster1 had a higher percentage of its farm households (58%) in either the poor or borderline food consumption category (Figure 3).

Figure 3: Food consumption groups by cluster

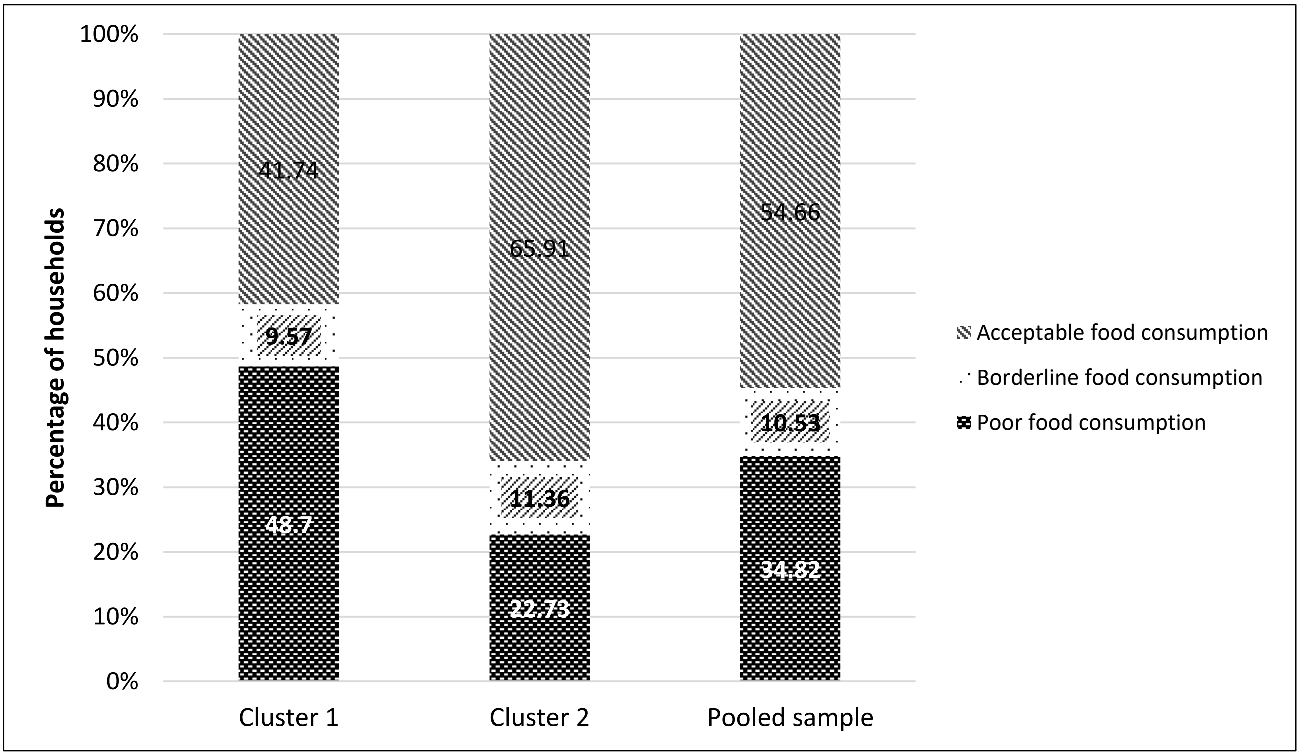
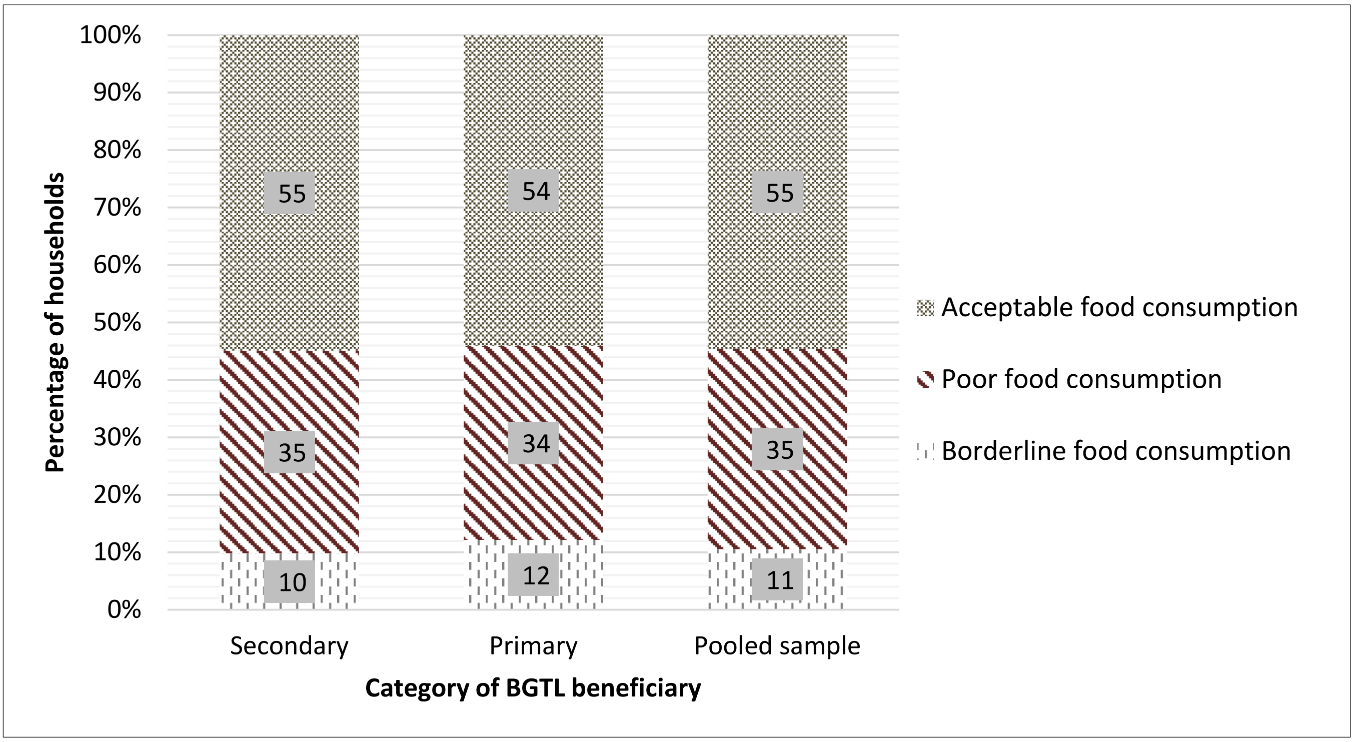


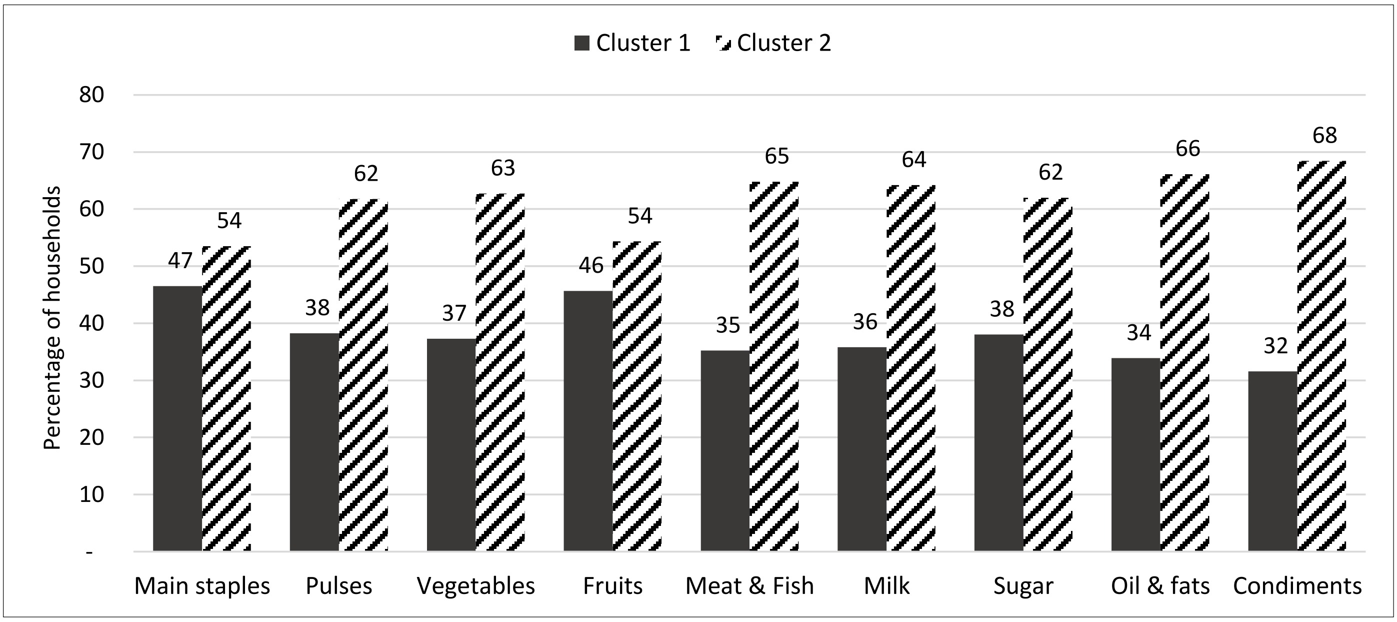
Figure 4 shows that about 46% of the primary beneficiaries of GBTL were between poor and borderline food consumption levels as compared to 45% of the secondary beneficiaries (Figure 4). Therefore, generally the two groups are almost similar in terms of food security.

Figure 4: Food consumption groups by beneficiary category



Exploring the food security variable in terms of dietary diversity as a social factor revealed that Cluster 1 households consumed a less diverse diet compared to Cluster 2. Although a high proportion of Cluster 1 farm households consumed fruits and staples, the proportion of Cluster 2 households that had consumed all the nine food groups in the last 7 days prior to survey was higher in all aspects (Figure 5). Results indicated that 65% of Cluster 2 households had consumed meat and fish compared to only 35% of Cluster 1 households. Milk was consumed by 36% of Cluster 1 households compared to 64% of Cluster 2 households.

Figure 5: Percentage of households that had consumed the different food types in the last 7 days prior to survey



Across agricultural activities from production, input access and marketing of produce, Cluster 2 households are generally more social than Cluster 1 households. A significantly higher percentage of Cluster 2 households are found to mind about what other family and community members will think about their actions while making farming decisions (Table 5). However, when it comes to non-farming business activity, more Cluster 1 households are socially sensitive about the implications of their action on society and family compared to Cluster 2 counterparts while making business decisions.

From a gender perspective, findings show that more Cluster 1 than Cluster 2 households with an adult male and female make decisions under duress not to cause trouble to the other partner. Similarly, more Cluster 1 than Cluster 2 households headed by a female adult are concerned about the impact of their decisions on their peers or community compared to households with adult male only (Table 6).

Table 5: Comparison of households' social indicators in agricultural production, marketing and business activity by cluster

	Social indicator statements (% respondents who agreed the statement is TRUE)				
Activity	**Clusters**	**My actions are determined by the situation. I don't really have an option**	**My actions are partly because I will get in trouble with someone if I act differently**	**I do what I do because I personally think it is the right thing**	**I do what I do so others don't think poorly of me**
Agricultural production	1	91.09	23.3***	98.21	9.71
	2	93.01	41.26	98	14.79
Getting inputs for agricultural Production	1	81.55	24.51	90.09	7.84
	2	85.21	33.8	95.27	12.77
The types of crops to grow for agricultural production	1	76.92***	22.33*	99.11	6.8**
	2	92.25	32.62	95.97	14.79
Taking crops to the market/marketing crops	1	58.25**	20.39	89.19	2.97
	2	73.24	20.71	91.78	5.67
Non-farm business activity	1	23.4	4.3	49.02**	0
	2	22.4	3.97	36.09	0.79

*Significance: *10%, **5%, ***1% (These are Chi square values)*

Table 6: Social indicators by type of household

	Social indicator statements (Percentage of respondents who agreed the statement is TRUE) by cluster							
	My actions are determined by the situation. I don't really have an option		**My actions are partly because I will get in trouble with someone if I act differently**		**I do what I do because I personally think it is the right thing**		**I do what I do so others don't think poorly of me**	
Household tyoe/ Clusters	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Male and female adult	69.51	67.53	72.1	63.03	67.78	70.46	62.63	65.13
Female adult only	21.7	19.81	18.88	16.53	23.93	17.72	25.25	20.39
Male adult only	8.79	12.65	9.01	20.45	8.29	11.82	12.12	14.47
Chi Square	Ch 2 (2) = 6.83 Pr = 0.03		Chi2 (2) = 13.76 Pr = 0.001		Chi2 (2) = 18.99 Pr = 0.00		Chi2 (2) = 0.94 Pr = 0.63	

Discussion

Understanding farming system variability can go a long way in designing best-fit farm adjustments, improved policies and innovations in order to meet development goals, including food security for millions of people around the globe (Alvarez et al, 2014). However, households are often selective about the innovations, technologies and policies which they take up. Households make decisions on choice of technologies and how they deploy them based on multiple factors such as profitability, riskiness, uncertainty, lumpiness of investment, and institutional constraints (Ghadim & Pannell, 2005; Feder et al, 2004). A farming family's social class affects intergenerational transfer of skills that may have a bearing on household uptake of technologies over time (Errington, 2002; Keyzer & Phimister, 2003).

Since differences in socio-economic characteristics have an effect on technology adoption (De Graaff et al.2008;Asfaw & Admassie, 2004; Somda et al., 2005), this section discusses the findings of a farm typology and social diversity analysis based on adoption of a promoted technology involving Growing Bananas with Trees and Livestock (GBTL) in three districts of Central Uganda.

Farm typologies

Principal Component Analysis (PCA) and Cluster Analysis (CA) yielded two well-structured clusters of farms among sampled households. Cluster 1 is land-scarce, while Cluster 2 is a more land-abundant. The land-abundance characteristic distinguishes the two among the remote-rural and urbanized location. While Cluster 1 households earn significantly more from livestock, Cluster 2 earns more from non-farm income sources, indicating the ability and affinity of the latter to sell their labour off-farm. Indeed the size of landholding, source of family incomes and soil erosion levels have been documented in Uganda to influence adoption of agroforestry-based technologies (Buyinza et al., 2008). Farmers with larger landholdings are less likely to adopt such technologies which explain the Cluster 2 farmers' affinity to trade their labour for off-farm incomes. This is however counter reasoning compared to the findings of Goswami et al. (2014) who argued that larger farms face less pressure for income because they produce more.

Given that cluster 2 households had more rooms per house, more educated household heads and significantly higher total farm labour costs, it is evident that these are wealthier households than cluster1. Their off-farm employment may be in formal jobs such as teaching rather than daily manual labour. In addition, Cluster 2 households are also found to earn or benefit more from fodder sales and feed of all agricultural farm incomes. Lapar & Ehui (2003) attributed the higher adoption of fodder trees among land-abundant households to their dual-purpose nature where they are used as hedgerows and animal feed. This implies that the land constrained households may find it less appealing to plant fodder which may impinge on their food and income security.

Farm enterprise diversity

There is a strong typology segregation when it comes to enterprise diversity among the two clusters. Cluster 1 households had more a diverse group of crops grown compared to Cluster 2. Although Cluster 1 households have less land as a production resource and few of them pay for labour compared to cluster two, many of them grew a wide range of crops as a risk-aversion strategy. In fact it was observed that these households engage in enterprises that require less labour, and grow short-term seasonal crops. As earlier indicated, the two clusters of farms differ significantly in terms of their social-economic setup. However, Goswami et al. (2014) argued that diversity in terms of economy among rural farms is not a problem per se but the proper planning for access to extension and other services. In fact, Thomas et al. (2002), Cornish et al. (2015) and Gangwar & Ravishankar (2016) advocated for diversity of farmers through promotion of crop-livestock enterprise mixes that come with advantages of improved soil fertility, household nutrition, and food and income security.

Food security and social diversity

The effect of land abundance, enterprise diversity and wealth status continued to distinguish Clusters 1 and 2 farm households. Cluster 1 households were less food secure with a majority at borderline or poor food consumption compared to Cluster 2. The relatively higher diversity of crop enterprises grown by Cluster 1 than Cluster 2 farming households was not reflected in the food diversity consumed. This is however explained by the level of commercialisation of food by Cluster 1 since it is evident they earn more incomes from farming than off-farm. This is counter to the findings of previous studies which found a positive link between crop diversity and food and income security (Kalavathi et al., 2010); Achonga et al., 2011; Achonga et al., 2015).In this study however, we conclude that in areas like Central Uganda close to the major urban market of Kampala of more market-oriented agriculture, households are driven to sell more and eat less of their own produce.

The two farming household clusters were found to be as socially diverse as they are in economic and enterprise terms. The social diversity of the two clusters revealed a number of decision making aspects that shape and determine adoption decisions among households. For instance, the economic diversity seems to combine with social diversity to influence decision making including decisions to adopt technologies. There was significant evidence to show that wealthier, more food secure and economically diverse Cluster 2 households were more socially sensitive than their Cluster 1 counterparts. This same argument was echoed by Padmaja et al. (2006) and Katungi (2007) that market incentives and household factor endowments combine with social capital to influence household and individual's social interactions and behaviors.

Conclusions

This paper investigated the typologies within the coffee-banana farming system of Central Uganda and their social and economic diversity. It further delved into understanding the linkages between diversity and food and income security. The study sought to explore how diverse the banana farms in central Uganda were and the effect of farmer heterogeneity on the ongoing use of the GBTL to which farm households were exposed during a validation project.

Data were collected from three districts in Central Uganda in a sample composed of 247 households. Analysis of data using Principal Component Analysis (PCA) and Cluster Analysis (CA) revealed two unique clusters that differed economically and socially. The first cluster of households (Cluster 1) comprised of 43% of the sample and Cluster 2 had 57% of the sample. Cluster 1 farming households were made up of smaller farms with a higher crop diversity than Cluster 2 which contained wealthier farms who earned more from off-farm sources. Cluster 1 was also a less food secure class of households that live near urban centres and sell more of the produce compared to Cluster 2.

Social diversity was also a defining aspect of the two clusters of households. The wealthier and more food secure Cluster 2 households were also more socially diverse and sensitive. The social diversity and sensitivity emanated from these households' behavior of decision making that considered what other household or community members may think about them while producing crops, rearing livestock, procuring inputs, marketing produce or engaging in off-farm business activity. Although driven by gender diversity differences between the two farm clusters, this sensitivity was less visible with the Cluster 1 of smaller farms with high crop diversities.

We could not reject the initial hypothesis that socially and economically diverse farm households take up technologies more readily, because no difference in goat raising technologies between the two clusters was found, about 25% for GBTL and 70% for traditional Banana + Goats. The primary beneficiaries compared to secondary beneficiaries adopted more of Banana + Goats +fodder (GBTL) and Banana + Fodder enterprise combinations. Similar factors for both clusters appear to drive technology uptake linked to goat raising - factor endowments such as land, demand for high-value goat meat and low investment costs for animals and feed sources within reach of a broad segment of farms in Central Uganda.

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