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ORIGINAL ARTICLE

Household livelihood diversification in rural Africa

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Abstract

Diversification is a common livelihood strategy for rural households in developing countries, with diversification being either a choice or necessity depending on individual household contexts. Using two waves of data (from 2009 and 2011) for 1773 households from eight countries in sub-Saharan Africa, we examined livelihood diversification and its drivers. We examined livelihood diversification by considering household involvement in three livelihood activities: crop, livestock, and non-farm. Results indicated that 40% of households conducted all three livelihood activities, but there was heterogeneity in diversity levels. We used a correlated random effects model to identify the factors that pushed or pulled households to diversify their activities. Access to non-agricultural credit was positively associated with livelihood diversity as it can catalyze involvement in non-farm activities. Drought had a negative effect on livelihood diversity. Area of crop land had a positive effect on the number of livelihood activities conducted. We found that 53% of households added or removed at least one livelihood activity between 2009 and 2011, and the addition of non-farm activities was the most common change. Our results demonstrated the dynamic nature of livelihoods and importance of shocks (such as drought) and resource endowments (land) in understanding household livelihood diversification.

KEYWORDS
agriculture, diversification, livelihoods

JEL CLASSIFICATION
Q12, Q15, Q18, O12, O31

1 | INTRODUCTION

Rural households in sub-Saharan Africa often encounter incomplete factor and product markets, making livelihood diversification a ubiquitous livelihood strategy (Barrett et al, 2001; Davis et al., 2017; De Janvry et al., 1991). Diversification opportunities are important to the livelihoods of rural households in sub-Saharan Africa, and diversification away from cropping into other activities, such as livestock and non-farm activities can increase income and improve food security (Barrett et al., 2001; Block & Webb, 2001; Ellis & Mdoe, 2003; Frelat et al., 2016; Reardon et al., 1992). Although specialization in specific activities can lead to economies of scale and therefore

improved efficiency, at the household scale diversification can help increase the resilience of livelihoods to climate, health, and market shocks (Block & Webb, 2001; Ellis, 1998; Scoones, 1998).

The reasons for and the implications of livelihood diversification are complex, but in general decisions to diversify are either "opportunity-led" and driven by pull factors or "survival-led" and driven by push factors (Barrett et al., 2001; Ellis, 2000). The factors that pull or push households to diversify and how diversification affects livelihoods varies by context (Barrett et al., 2001; Bigsten & Tengstam, 2011). The recent increase in the availability of panel data from sources such as the Living Standards Measurement Study-Integrated Surveys on Agriculture has seen a greater focus on examining changes in livelihood diversification over time within specific countries (Asfaw et al., 2018; Dedehouanou & Peak, 2020; Djido & Shiferaw, 2018; Dzanku, 2015; Loison, 2019). Understanding if livelihoods are transient, that is switching livelihood activities over time, is important because empirical evidence suggests that transient households are more likely to have lower levels of asset wealth or consumption expenditure than non-transient households, such as in Ghana (Dzanku, 2015). These country-specific findings beg the question as to the extent of livelihood diversification and transiency across other locations in sub-Saharan Africa across a spectrum of socio-economic and biophysical conditions, and also the factors that affect this diversification.

The objectives of our study were threefold: (1) to examine the heterogeneity in the number and combination of rural household livelihood activities; (2) study the extent of transiency in livelihood activities; and (3) examine the factors that influence livelihood diversity. The three livelihood activities were crop, livestock, and non-farm. In our study, transiency was if a household moves from only having one livelihood activity to more than one livelihood activity, or the reverse, between the two survey rounds. Data for our study came from two waves of household surveys from eight rural villages in six farming systems across eight countries in sub-Saharan Africa in 2009 and 2011. The data were collected as part of the Millennium Villages project that was a 10-year, multisector, rural development project initiated in 2005 (Sanchez et al., 2007).

2 | METHODS

2.1 | Overview of methods and study context

To examine the livelihood strategies of rural agricultural households, we used household survey data (Section 2.3) collected as part of the Millennium Villages project (Section 2.1). Our analysis of these data was informed by the Sustainable Rural Livelihoods framework (Section 2.2), and this analysis included exploratory descriptive statistics, regression analysis with a correlated random effects model to examine drivers of livelihood diversity (Section 2.4), and the computation of transition probabilities to examine livelihood transiency (Section 2.4).

The Millennium Villages project covered 12 village clusters (a village cluster was typically a group of several small villages), which together covered the farming systems used by 90% of rural households in sub-Saharan Africa (Dixon et al., 2001; Sanchez et al., 2007; Figure 1A). The village clusters, henceforth called villages, on average, had 45,000 persons (~7000 households) ranging from 25,000 to 80,000 persons (Mitchell et al., 2018). For detailed information on country and village selection see Sanchez et al. (2007) and Mitchell et al. (2018).

Of the 12 villages, eight villages were selected for our current study because they had similar household survey tools regarding the three livelihood activities therefore permitting the study of livelihood diversification, and the household data were collected over the same 2 years for all households giving a 2-year panel of data for analysis. The eight villages were: Bonsaaso, Ghana; Pampaida, Nigeria; Potou, Senegal; Tiby, Mali in West Africa, and; Mayange, Rwanda; Mbola, Tanzania; Mwandama, Malawi; and Ruhiira, Uganda in East and Southern Africa. The farming systems, livelihood activities, and rainfall in each village varied (Table 1).

The Millennium Villages project worked with communities and local governments to address key areas that would facilitate achieving the Millennium Development Goals (Sanchez et al., 2007). Interventions in agriculture, business, education, health, infrastructure, and management were implemented over time and varied with the needs of the different villages. During the first three to 5 years of the Millennium Villages project (the time period of interest for our study) the primary focus was on "quick wins": subsidization and provision of mineral fertilizers and improved seeds; distribution of free long-lasting insecticide-treated bednets and antimalarial medications; elimination of user fees for primary schools and for maternal and child health services; expansion of school meals programs; and construction or improvement of roads and other infrastructure such as schools and health clinics (Mitchell et al., 2018). The financing of interventions followed the UN Millennium Project's recommendations (UN Millennium Project, 2005), with the project spending an average of USD 66 per person per year in the project's first 5 years (Mitchell et al., 2018). The series of investments in the villages were available to all in the villages and as such all households in our study were exposed to these investments. Our aim was to examine the role of

TABLE 1 General description of the farming system and livelihood activities across villages

Village, Country	Farming system	Livelihood activities	Average annual rainfall (mm)
Bonsaaso, Ghana	Tree Crop	Rainfed maize, plantain, cassava, and cocoyam are key crops and livestock rearing mainly includes sheep, goats, and chicken. Cacao is a high value crop grown by most households.	1479
Pampaida, Nigeria	Cereal-Root (Sudan savanna)	Sorghum, maize, soybean, and upland rice dominate crop patterns. livestock rearing is important with transhumance practiced during the dry season mainly by agro-pastoralists.	1128
Potou, Senegal	Agro-pastoral	Onions, groundnut, millet, and groundnuts are crops grown. Cattle keeping is common. Artisanal fishing and fish processing is practiced by a few households. Household members are employed by fish merchants in the coastal zone. Market gardening of vegetables is a key income-generating activity.	334
Tiby, Mali	Agro-pastoral	Rice, millet, and sorghum are key annual crops grown, with rice being mainly a cash crop. Small-scale irrigated vegetable gardens for income generation also exist. Livestock are an important asset.	591
Mayange, Rwanda	Highland Perennial	Cassava, maize, sorghum, and beans are common crops grown. Cassava is used for food but is also sold as a cash crop. Livestock keeping, mainly goats and cattle, are practiced on small scale.	1050
Mbola, Tanzania	Maize Mixed (unimodal)	Maize constitutes the major staple crop while tobacco is the major cash crop. Livestock is an important part of the farming system concentrated in a few ethnic groups.	900
Mwandama, Malawi	Cereal-Root (Southern miombo)	Maize constitutes the major staple crop grown, along with beans. Livestock rearing is uncommon. Household members often work on commercial estates, typically growing tobacco and maize.	1150
Ruhiira, Uganda	Highland Perennial	Main activities include production of banana, Irish potatoes, beans, maize and livestock. Bananas and Irish potatoes are main cash crops.	1043

Note: Farming system classification from Dixon et al. (2001). Average annual rainfall for the years 1981–2008 obtained from Stackhouse et al. (2018). Figure 2A provides annual rainfall per village over time.

additional drivers of livelihood diversification for households, which were all in the Millennium Villages project, and we did not aim to conduct an impact evaluation of the Millennium Villages project.

2.2 | Conceptual framework

We used the Sustainable Rural Livelihoods framework (Scoones, 1998) as a basis for examining the livelihood strategies of rural agricultural households. In the framework, households draw upon five main types of capital to influence their livelihood strategies: (1) human (education, labor); (2) natural (land, water); (3) financial (savings, credit); (4) physical (roads, infrastructure); (5) and social (informal safety nets and organization memberships). Livelihood strategies include income diversification, agricultural intensification, and migration. An important part of the framework is the context that households operate in and this context includes exposure to different sources of vulnerability such as seasonality and shocks, such as weather and output price variability (Barrett et al., 2001; Ellis, 2000; Nielsen et al., 2013; Scoones, 1998). The framework provides a conceptual basis to examine and understand the factors that affect the choice of livelihood strategies and how these factors interact. The endowment of capitals and context are correlated to choices of the livelihood activities of households to improve or sustain their livelihood. The sustainable aspect focuses on how households can use their capital to overcome moments of vulnerability due to health, climatic, and market shocks. The framework links the context (including location) and capitals to help better understand how rural households select their activities (Scoones, 1998). We used this framework to guide our selection of factors that may influence livelihood diversity (Section 2.4).

2.3 | Data

The Millennium Villages project used a stratified random data selection process to select 300 households within a village (Adkins et al., 2012; Mitchell et al., 2018). We used data collected from eight villages for 2009 and 2011, the 3rd and 5th year of the project. The recall survey questionnaires were administered in 2009/2010 covering the

TABLE 2 Description of variables used in the analysis

Variable	Description
Livelihood diversity Index	An index to capture diversity as the number of livelihood activities conducted (range 1–3).
Transient	If household moved from one livelihood activity to multiple livelihood activities, or the reverse, during the study period (1 = yes, 0 = no).
Crop Index	Squared ratio of the number of crops grown by the household divided by the maximum number of crops grown by all households in the household's village (range 0 to 1).
Non-farm Index	Count index of the number of non-farm activities (temporary non-farm employment, business enterprises, and salaried employment) the household engaged in (range 0 to 3).
HHH Age (HC)	Age in years of the household head.
HHH Gender (HC)	Gender of the household head (1 = female, 0 = male).
Household size (HC)	Total number of household members.
HHH Education (HC)	Binary variable indicating whether household head attended at least primary school or had no formal education (1 = at least primary school, 0 = no formal education).
Working Age (HC)	Total number of adults in a household between the ages of 15 and 64 years.
Land cultivated (NC)	Total cultivated land that the household used for crop production in hectares.
Non-Ag. Credit (FC)	Binary variable indicating whether household obtain credit for non-agricultural activities (1 = yes, 0 = no).
Ag. Credit (FC)	Binary variable indicating whether household obtain credit for agricultural inputs (1 = yes, 0 = no).
Death in household	Binary variable indicating whether a household had a death of a household member (in the year) (1 = yes, 0 = no).
Drought	Binary variable indicating whether the household reported experiencing a drought (1 = yes, 0 = no).

2008/09 crop growing season, and in 2011/12 covering the 2010/11 crop growing season. We, therefore, used the last crop growing season that data was collected to denote the year data was collected. We selected these two survey years because these were the only survey years that explicitly included questions on non-farm activities. Our study used data from households interviewed in both years (balanced panel) leaving a total of 3546 observations with 1773 households in each year.[1]

The household survey included modules on agricultural crop production, livestock ownership and production, livelihood strategies, sources of income, food and non-food consumption expenditure, household and farm assets, credit use and in-kind transfers, and household livelihood shocks. We used these modules to compute indexes for livelihood diversity and compute variables to capture factors that affect diversification based on the Sustainable Rural Livelihoods framework. These variables were used in the regression analysis of livelihood diversification choices and were used in the computation of transition probabilities. Table 2 lists and describes the variables used in our study. The details on variable selection, the capitals they represent, and their computation are presented below.

Variables were selected based on the Sustainable Rural Livelihoods framework with each variable belonging mostly to one of the five capitals or the overall vulnerability context (shocks) of the household. Age of household head (human capital) is an indicator of work experience (Block & Webb, 2001; Minot, 2006), gender of household head (human capital) may affect several household livelihood dimensions such as access to remunerative non-farm activities (Birthal et al., 2014; Canagarajah et al., 2001; Loison, 2019). Household size (human capital) can capture consumption demand. The number of working age adults (human capital) reflects the availability of labor, which can influence incentives to diversify into multiple livelihood activities (Abdulai & CroleRees, 2001; Corral & Radchenko, 2017). The education level of the household head (human capital) reflects skills and ability to acquire information, increase productivity, or engage in remunerative non-farm activities (Babatunde & Qaim, 2009; Minot, 2006). The area of land cultivated (natural capital) has been shown to have mixed effects on livelihood diversity. Cultivated land may reflect availability of land for crop production and the ability of the household to specialize in agricultural production to ensure food security (Bigsten & Tengstam, 2011; Minot, 2006). On the contrary, cultivated land may act as collateral or an asset that can be

[1] The attrition rate across all villages was 24%. Existing household survey studies in sub-Saharan Africa had attrition rates of 18%–23% (Bigsten & Tengstam, 2011; Corral & Radchenko, 2017; Michler & Josephson, 2017). For testing attrition in our sample, we follow a similar approach to these existing studies by testing whether attrition was a pervasive problem on our outcome variable in order to adjust for it in our regression analysis by using inverse probability weights.

liquidated to allow households to venture into new non-cropping activities (Reardon et al., 1992). Households with larger cultivated land areas (farm sizes) might diversify to accumulate wealth (Rahut & Scharf, 2012) compared to farms with smaller cultivated land areas that may diversify to survive (Ellis, 1998). Agricultural and non-agricultural credit capture households' access to financial capital, and credit can be used to expand into new businesses or purchase physical capital or technologies (Birthal et al., 2014; Scoones, 1998).

In addition to the above variables, we included exposure to different shocks (vulnerability) in our regression model. Resilience to climatic, market, and health shocks are linked to the choice of livelihood activities (Mbiba et al., 2019; Quandt, 2018). Households might diversify livelihood activities to buffer against drought since droughts can simultaneously affect crop production and forage available for animal feed (Ellis, 1998; Minot, 2006). The death of a household member can reduce labor availability (and hence livelihood activities) and may cause disruptions to family life.

2.4 | Analytical approach

This section describes the variables used in the analysis and their curation in Table 2. Post primary education included secondary school, technical institutes, university, and adult education. Households reporting access to credit for mineral fertilizer or seeds, purchase of livestock, and purchase of agricultural equipment were all categorized as having accessed to "agricultural credit." The enumerator manual defined credit as "cash that comes into a household as a loan and has an expectation of repayment with or without interest." The question was: "What was the purpose of these credit, loans or payment plans?" Two livelihood shocks included the death of a household member and drought. The drought variable was based on the household's subjective opinion if they experienced a drought, to warrant it being called a shock. The survey question asked: "Over the past 12 months, was your household severely affected negatively by any of the following events…?" The options included: (a) "Drought" and (b) "Death in household."

A binary variable was constructed for each livelihood activity that the household reported. We used a simple count index to measure livelihood diversity based on the three major livelihood activities typically conducted by rural households: crop, livestock, and non-farm activities (Minot, 2006; Nielsen et al., 2013). This simple count index provided a parsimonious approach to examine diversity in livelihood activities, as illustrated in existing studies (Michler & Josephson, 2017; Minot, 2006; Waha et al., 2018). We explored the use of two other measures of diversification: the Herfindahl index of concentration and the Simpson's index of diversity (Herfindahl, 1950; Simpson, 1949). But these measures focus on the number and share of a given activity and to adequately use these measures at the household scale we would need a common unit to aggregate across crop, livestock, and non-farm activities We therefore chose the count index. Our livelihood diversity index was the sum of the three activities (crop, livestock, and non-farm) reported by each household. To examine diversity within crop and non-farm activities, we computed a crop and non-farm index. The crop index is the squared ratio of the total number of crops grown by the household divided by the maximum number of crops grown by all households in the household's village, previously used by Michler and Josephson (2017). The non-farm index was computed as the number of non-farm activities (temporary non-farm employment, business enterprises, and salaried employment) reported by the households. A binary variable was constructed for each livelihood activity that the household reported. A household was classified as being transient if it switched from having any level of diversity (defined as conducting more than one of the three livelihood activities) in 2009 to having no diversity (defined as conducting only one of the three livelihood activities) in 2011 or from having no diversity in 2009 to having any level of diversity in 2011.

We used a correlated random effects model (Mundlak, 1978) to examine drivers of livelihood diversity:

$$LD_{it} = \alpha + \boldsymbol{\beta X_{i,t}} + c_i + \mu_{it} \quad (1)$$

$$\varepsilon_{i,t} = c_i + \mu_{it} \quad (2)$$

where LD represents the livelihood diversity index of household i at time t; X_{it}, the vector of observed explanatory variables, and α and β are parameters to be estimated. Our measure of livelihood diversity is a count of the number of livelihood activities. We also used the same correlated random effects model to examine drivers of non-farm diversity (Table 3).

The error term (Equation 2) for Equation (1) consists of two components: μ_{it}, is the unobserved time-varying factors that may affect livelihood diversification such as policy changes, and; c_i the time-invariant variable that captures unobserved household-specific factors that may vary between households and may affect the household's livelihood diversification. The assumption that the observed (measured) variables are uncorrelated with the unobserved (latent) variables can be relaxed by using the correlated random effects model (Chamberlain, 1982; Mundlak, 1978; Ricker-Gilbert et al., 2011). In the correlated random effects model, the unobserved individual effects are treated

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TABLE 3 Household descriptive statistics pooled (2009 and 2011)

Variables	All eight villages ($n = 3546$)	Bonsaaso, Ghana ($n = 396$)	Pampaida, Nigeria ($n = 480$)	Potou, Senegal ($n = 462$)	Tiby, Mali ($n = 492$)	Mayange, Rwanda ($n = 390$)	Mbola, Tanzania ($n = 454$)	Mwandama, Malawi ($n = 418$)	Ruhiira, Uganda ($n = 454$)
Livelihood diversity Index (range 1–3)	2.3 (CV = .31)	1.8	2.4	2.6	2.5	1.8	1.9	2.4	2.5
Transient (1 = yes)	19%	43%	15%	4%	6%	35%	31%	19%	9%
Crop Index (range 0–1)	.27 (CV = .62)	.22	.32	.18	.24	.31	.28	.32	.30
Non-farm Index (range 0– 3)	.69 (CV = 1.2)	.57	.93	1.10	.83	.31	.18	.73	.76
Human Capital									
HHH Age (years)	48 (CV = .31)	48	44	47	53	50	49	47	45
HHH Gender (1 = female)	17.6%	24.4%	.8%	12.6%	1.4%	21.5%	19.2%	35.6%	30.6%
Household size	7 (CV = .74)	5	8	10	14	5	6	4	5
Working Age	4 (CV = .79)	3	4	5	7	3	3	2	2
HHH Education (1 > = primary)	70%	67%	55%	75%	72%	68%	65%	83%	73%
Natural Capital									
Land cultivated (Ha)	2.57 (CV = 1.3)	3.95	3.20	.70	7.50	.54	1.67	1.75	.64
Financial Capital									
Non-Ag. credit (1 = yes)	15.6%	10.1%	5.6%	22.9%	14.4%	6.7%	2.9%	11.7%	48.5%
Ag. credit (1 = yes	24.4%	4.3%	32.5%	36.4%	19.7%	2.3%	46.5%	40.7%	8.8%
Shocks									
Death in household (1 = yes)	11.7%	9.6%	21.7%	9.5%	22.6%	3.3%	11.7%	4.8%	7.3%
Drought (1 = drought)	27.3%	23.0%	14.8%	.2%	32.1%	22.3%	43.6%	14.6%	65.0%

Note: HHH = Household head. In the first row, numbers in parentheses are household sample sizes. For the non-percentage values, the values reported are averages with the coefficient of variation (CV) in parentheses for the full sample, defined as standard deviation divided by average.

as random but in the fixed effects model the relationship is left unspecified. This allows the correlated random effects model to estimate coefficients of time-invariant variables (Chamberlain, 1982; Wooldridge, 2019). The inclusion of the averages of all time-varying continuous variables in Equation (1), can control for time-invariant unobserved heterogeneity as the fixed effects model circumventing the problem of incidental parameters (Wooldridge, 2019). Our study applied the correlated random effects model because it provides estimates for time-invariant factors (such as village location). The standard errors are clustered at the household level to make them robust to heteroscedasticity and serial correlation (Wooldridge, 2010). The model also includes a location variable for each village that may control for some, but not all, cluster effects (Abadie et al., 2017). We estimated a correlated random effects negative binomial model that accounts for overdispersion in the dependent variable conditional on the explanatory variables. When overdispersion is detected, the negative binomial model may provide a better fit than a Poisson model (Cameron & Trevidi, 2013; Fávero et al., 2020; Yang et al., 2009), which assumes that the mean equals the variance for the dependent variable.

Since our study used a balanced panel of households interviewed in both years, there was potential for attrition bias. We therefore assessed for attrition and adjusted for attrition bias by using inverse probability weights. For the correlated random effects model estimation, we applied a natural logarithmic transformation to the continuous variables and we added a constant of 1 to continuous variables that took on a zero value. Finally, we calculated transition probabilities to examine households' transiency over the study period (2009–2011). Our method on transition probabilities followed the method of Dzanku (2015).

3 | RESULTS

3.1 | Household characteristics and livelihood activities

Household characteristics (Table 4) and the number of livelihood activities (Figure 1) varied across villages and survey waves. Eighty-six percent of households reported engaging in more than one activity. The mode number of livelihood activities reported was two activities over the study period, with the village average ranging from 1.78 to 2.63. Forty percent of the households reported three activities over the study period. Crop activity was reported by 98% of the households (with a range of crops planted, Table 5A) followed by livestock activity at 78%, and non-farm activities at 50% (range 17%–76%). Differences in agroecological conditions among the villages (Table 1) mean that the average area of household land holding varied substantially across the villages (Table 4), with smaller areas in Senegal, Uganda, and Rwanda and larger areas in Ghana and Mali.

There was an increase in the number of households reporting all three livelihood activities in 2011 compared to 2009 (Figure 1). Apart from the average number of livelihood activities, we observed changes in the number and combinations of livelihood activities that households engaged in from 2009 to 2011. On average across all villages, the four most common livelihood activity combinations reported in rank order were; (1) all three (crop, livestock, non-farm); (2) crop and livestock; (3) crop only; and (4) crop and non-farm (Figure 1 and Table 5). Among the livelihood activities, there was a 7% increase in reporting of non-farm activities from 2009 to 2011, the highest increase of the three activities (Figure 1). In the next section, we examine the drivers of livelihood diversity and then non-farm diversity.

3.2 | Factors influencing livelihood diversity

The results on livelihood diversification indicated that households with larger cultivated land areas and those that accessed credit for non-agricultural and agricultural activities had higher levels of livelihood diversity than households with smaller cultivated land areas and or who did not access credit (Table 3). Households that indicated experiencing a drought had lower levels of livelihood diversity than those that did not report experiencing a drought. The Poisson model had similar results to the negative binomial model in terms of the significant variables and the direction of effect on livelihood diversity (Table 8A).

For drivers of non-farm diversity, higher educational attainment was associated with greater non-farm diversity, but larger cultivated areas were associated with lower non-farm diversity (Table 3). In addition, households with more working age adults and those that accessed credit from non-agricultural and agricultural activities had higher levels of non-farm diversity than households with fewer working age adults and/or who did not have access to credit. Table 9A provides additional analysis on the drivers of diversity with the crop activity and drivers of the three specific non-farm activities.

3.3 | Transient livelihoods

Nineteen percent of households had a transient livelihood; they moved from diversified in 2009 to not diversified in 2011, or the reverse (Table 6). The results, on average, indicated that households that were diversified in 2009 remained diversified in 2011 (Table 10A).

TABLE 4 Number of livelihood activity combinations from 2009 to 2011

	Activities in 2011						
Activities in 2009	**Crop only**	**Livestock only**	**Non-Farm only**	**Crop & Livestock**	**Crop & Non-Farm**	**Livestock & Non-Farm**	**Crop & Livestock & Non-Farm**
Crop only ($n = 218$)	**78 (36%)**	0 (0%)	4 (2%)	52 (24%)	33 (15%)	0 (0%)	51 (23%)
Livestock only ($n = 4$)	0 (0%)	**0 (0%)**	0 (0%)	2 (50%)	1 (25%)	0 (0%)	1 (25%)
Non-Farm only ($n = 14$)	1 (7%)	0 (0%)	**1 (7%)**	4 (29%)	2 (14%)	2 (14%)	4 (29%)
Crop & Livestock ($n = 717$)	96 (13%)	0 (0%)	2 (0%)	**331 (46%)**	35 (5%)	0 (0%)	253 (35%)
Crop & Non-Farm ($n = 161$)	41 (25%)	0 (0%)	8 (5%)	23 (14%)	**30 (19%)**	0 (0%)	59 (37%)
Livestock & Non-Farm ($n = 20$)	2 (10%)	0 (0%)	0 (0%)	1 (5%)	2 (10%)	**4 (20%)**	11 (55%)
Crop & Livestock & Non-Farm ($n = 639$)	32 (5%)	0 (0%)	8 (1%)	157 (25%)	49 (8%)	3 (0%)	**390 (61%)**

Note: The first column indicated the number of households that were engaged in those given activities in 2009. The preceding seven columns indicate which activities they transitioned to in 2011. For example, in row 3; in 2009, 218 households were engaged in crop only activity, but in 2011, 78 (36%) of these household remained as crop only, 4 (2%) engaged in non-farm only, 52 (24%) engaged in crop and livestock activities, 33 (15%) in crop and non-farm, and 51 (23%) in all three activities. Rows 4–9 can be interpreted similarly. Table 5 provides village-level changes in livelihood combinations. Table 6 presents data on non-farm activity combination for each village over the study period.

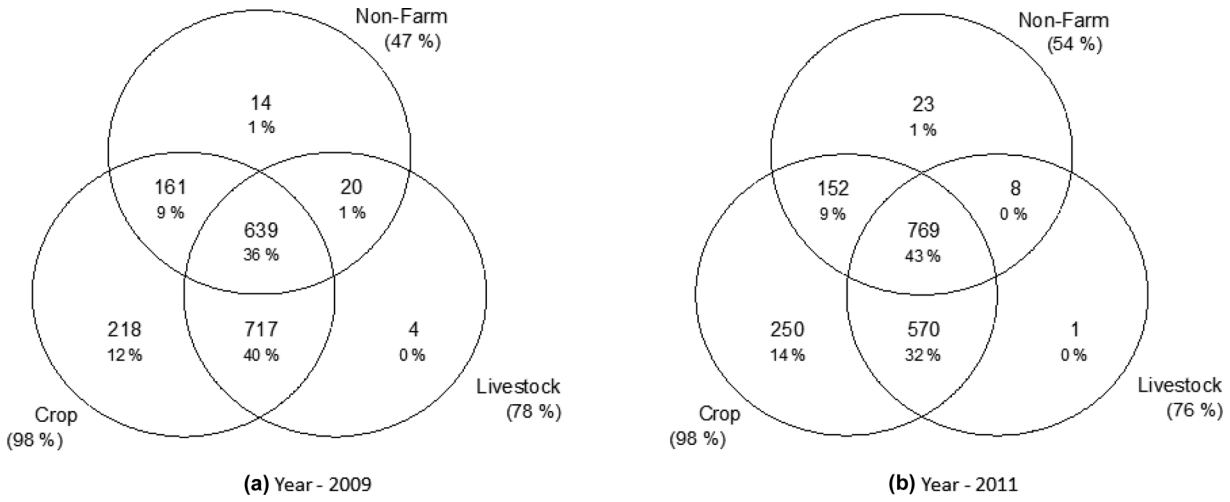

FIGURE 1 Distribution of number and percent of the 1773 households according to the type(s) of livelihood activities reported across all eight villages by year. Table 1A reports in each village the type of non-farm activity reported. Table 2A reports the type of livelihood activity conducted in each village. Table 4A reports the change in livelihood activity across the years in each village. Figure 3A reports the different livestock species reared in each village

Transiency behavior varied across villages. Of the total transient households, those that diversified moved from crops only to combinations of crop and livestock (38%), crop and non-farm (24%), and all three activities (38%) (Table 5). Households that moved out of diversity, indicated crop only or non-farm as the sole activity to which they moved into.

4 | DISCUSSION

Using crops, livestock, and non-farm activities as three broad livelihood activities for rural households in eight countries across rural sub-Saharan Africa, we find that most households engage in more than one livelihood activity. Examining the portfolio of the households' livelihood activities reveals that on average 86% of the households had more than one livelihood activity and 40% reported all three activities over the study period. Previous studies have suggested that livelihood diversification by rural households in developing countries is a pervasive and enduring strategy (Ellis, 1998; Reardon, 1997). Our results complement these previous studies and our results also examine the livelihood combinations that underly this common livelihood strategy of diversification.

TABLE 5 Estimation results for the drivers of livelihood and non-farm diversity from negative binomial correlated random effects models

	Dependent variable: Livelihood diversity index		Dependent variable: Non-farm count index	
Variables	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
HHH Age (Ln)	.127	.138	.113	.198
HH Gender (1 = Female)	-.022	.035	.064	.047
HHH Education (1 > = Primary)	.036	.025	.1**	.031
Household Size (Ln)	.008	.069	-.051	.085
Land cultivated (Ln)	.134***	.036	-.079**	.040
Working age adults (Ln)	.106	.083	.268***	.101
Non-Ag. credit (1 = Yes)	.113***	.031	.225***	.040
Ag. credit (1 = Yes)	.085***	.024	.118***	.034
Death in Household (1 = yes)	-.001	.031	.032	.039
Drought (1 = drought)	-.081**	.027	-.039	.034
Panel (1 = 2011)	.022	.021	.135***	.025
Village (base = Bonsaaso)				
Pampaida	.47***	.047	.254***	.066
Potou	.706***	.058	.177**	.075
Tiby	.455***	.055	.067	.073
Mayange	.048	.057	-.341***	.061
Mbola	.089*	.049	-.49***	.053
Mwandama	.575***	.055	.114*	.062
Ruhiira	.716***	.056	.061	.066
Chi-squared	1025***		552.2***	

Note: Sample size was 3546 households in both models, 1773 in each year. For overdispersion in the dependent variable, our test rejected the null hypothesis of equidispersion in both equations favoring the estimation of a negative binomial model over the Poisson model (Table 7A). Table 9A reports estimation results for drivers of individual non-farm activities. The attrition was non-random therefore inverse probability weights were included to control for attrition bias (Table 11A). *10% significance level, ** 5% significance level, *** 1% significance level; HHH, household head; Ln, natural logarithm.

TABLE 6 Diversification and transiency in livelihood activities

Village	Transient	Non-transient and diversified	Non-transient and not diversified
Bonsaaso	43%	41%	16%
Pampaida	15%	85%	0%
Potou	4%	96%	0%
Tiby	6%	94%	0%
Mayange	35%	49%	16%
Mbola	31%	63%	6%
Mwandama	19%	78%	3%
Ruhiira	9%	91%	0%
Average	19%	76%	5%

Note: For the non-transient households, diversified households reported more than one livelihood activity in both surveys and not diversified households reported one livelihood activity in both survey rounds. Table 10A presents the transition probabilities from 2009 to 2011.

We found that crop production remains the most common activity reported by households, but non-farm activities are also commonly reported. Davis et al. (2017) also found similar results in a study of 41 national household surveys; in 22 of those countries crop production activities were the major activities for rural households in sub-Saharan Africa. For specific activities, crop and livestock activities are common and complementary agricultural activities (Davis et al., 2017). Although we found that crop and livestock activities are the most common combination of two livelihood activities, the trend in our dataset was for households to add non-farm activities to crop and livestock activities, similar to Nagler and Naude (2017). Non-farm activities differed across villages but households in agro-pastoral farming systems reported the highest average number of non-farm activities. Frelat et al. (2016) indicated the importance of households' engagement in non-farm activities for food security across sub-Saharan Africa calling for the diversification of agricultural development strategies to include improving market access and off-farm opportunities.

There was a need to understand what might drive livelihood diversity at any one point in time since we observed spatial variation in livelihood diversity (Table 4), as also

discussed by Block and Webb (2001). Area of cultivated land (farm size) was associated with more diverse livelihoods, contrary to some studies (Minot, 2006). Households with larger farm sizes may be more willing to take risk and venture into non-farm activities since they might have greater revenue from agricultural production investment in off–farm activities or use part of their land as collateral (Reardon, 1992). This outcome emphasizes the value of land as a key capital resource that provides opportunities for households to diversify (Ellis, 1998; Rahut & Scharf, 2012).

Non-agricultural credit and agricultural credit had a positive effect on livelihood diversity. This would be explained as access to credit may provide options to establish non-farm businesses (Ellis, 1998; Gautam & Andersen, 2016; Nagler & Naude, 2017). Nagler and Naude (2017) studied non-farm enterprises in six countries in sub-Saharan Africa and concluded that access to credit was associated with a higher likelihood to open a non-farm enterprise.

Households that self-reported drought had lower levels of livelihood diversity. Droughts may have adverse effects on numerous activities simultaneously such as reduced crop production and reduced availability of forage to feed animals, which might imply selling livestock as a tactical management option (Barrett et al, 2001). Drought may indirectly then affect business enterprises (non-farm activity) that depend on agricultural production (Ellis, 1998).

There is a continued debate on whether livelihood diversification is a common strategy among rural households in developing countries, and if this diversification is an enduring strategy (Dedehouanou & McPeak, 2020; Dzanku, 2015; Ellis, 1998; Reardon, 1997). Our results suggested that diversified households were more likely to stay diversified, which may be contrary to past assertions that rural households move in and out of livelihood activities as a trial and error process (Tellegen, 1997). This result provides an alternative perspective to Dzanku (2015) who found that diversification is temporary, in some contexts. Transient households were more likely to diversify into non-farm activities while still maintaining some of their crop and livestock production activities.

5 | CONCLUSION

Diversification is a common livelihood strategy across rural sub-Saharan Africa. Diversification as a livelihood strategy depends on several interrelated factors including the context factors households face (including vulnerability to shocks) and the different types of capitals that households draw upon to generate their livelihood. We found that major drivers of livelihood diversity were being pulled by farm size and access to credit. Non-farm activities were reported by 50% of the households, but activity types varied by location. The diversity of activities within and between the livelihood activities shed light on how 19% of households were transient and whether actions to increase access to credit to explore non-farm activities can increase rural household diversity.

Shocks related to drought contributed to explaining declines in livelihood diversity. Taking our results together highlights the need for multi-sectoral interventions aimed at livelihood improvement to be sensitive to the role of both capital and shocks in shaping livelihood strategies such as diversification, especially given the heterogeneity found among households in sub-Saharan Africa.

REFERENCES

Abadie, A., Athey, S., Imbens, G. W., & Wooldridge, J. (2017). *When should you adjust standard errors for clustering? (No. w24003)*. National Bureau of Economic Research.

Abdulai, A., & CroleRees, A. (2001). Determinants of income diversification amongst rural households in Southern Mali. *Food Policy*, *26*(4), 437–452.

Adkins, E., Oppelstrup, K., & Modi, V. (2012). Rural household energy consumption in the millennium villages in Sub-Saharan Africa. *Energy for Sustainable Development*, *16*(3), 249–259.

Asfaw, S., Pallante, G., & Palma, A. (2018). Diversification strategies and adaptation deficit: Evidence from rural communities in Niger. *World Development*, *101*, 219–234.

Babatunde, R. O., & Qaim, M. (2009). Patterns of income diversification in rural Nigeria: Determinants and impacts. *Quarterly Journal of International Agriculture*, *48*(4), 305–320.

Barrett, C. B., Reardon, T., & Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics, and policy implications. *Food Policy*, *26*(4), 315–331.

Bigsten, A., & Tengstam, S. (2011). Smallholder diversification and income growth in Zambia. *Journal of African Economies*, *20*(5), 781–822.

Birthal, P. S., Negi, D. S., Jha, A. K., & Singh, D. (2014). Income sources of farm households in India: Determinants, distributional consequences and policy implications. *Agricultural Economics Research Review*, *27*(1).

Block, S., & Webb, P. (2001). The dynamics of livelihood diversification in post-famine Ethiopia. *Food Policy*, *26*(4), 333–350.

Cameron, A. C., & Trivedi, P. K. (2013). *Regression analysis of count data* (Vol., 53). Cambridge University Press.

Canagarajah, S., Newman, C., & Bhattamishra, R. (2001). Non-farm income, gender, and inequality: Evidence from rural Ghana and Uganda. *Food Policy*, *26*(4), 405–420.

Chamberlain, G. (1982). Multivariate regression models for panel data. *Journal of Econometrics*, *18*(1), 5–46.

Corral, P., & Radchenko, N. (2017). What's so spatial about diversification in Nigeria? *World Development*, *95*, 231–253.

Davis, B., Di Giuseppe, S., & Zezza, A. (2017). Are African households (not) leaving agriculture? Patterns of households' income sources in rural Sub-Saharan Africa. *Food Policy*, *67*, 153–174.

De Janvry, A., Fafchamps, M., & Sadoulet, E. (1991). Peasant household behaviour with missing markets: some paradoxes explained. *The Economic Journal*, *101*(409), 1400–1417.

Dedehouanou, S. F., & McPeak, J. (2020). Diversify more or less? Household income generation strategies and food security in rural Nigeria. *The Journal of Development Studies*, *56*(3), 560–577.

Dixon, J. A., Gibbon, D. P., & Gulliver, A. (2001). Farming systems and poverty: Improving farmers' livelihoods in a changing world. Food and Agriculture Organization.

Djido, A. I., & Shiferaw, B. A. (2018). Patterns of labor productivity and income diversification–Empirical evidence from Uganda and Nigeria. *World Development*, *105*, 416–427.

Dzanku, F. M. (2015). Transient rural livelihoods and poverty in Ghana. *Journal of Rural Studies*, *40*, 102–110.

Ellis, F. (1998). Household strategies and rural livelihood diversification. *The Journal of Development Studies*, *35*(1), 1–38.

Ellis, F. (2000). The determinants of rural livelihood diversification in developing countries. *Journal of Agricultural Economics*, *51*(2), 289–302.

Ellis, F., & Mdoe, N. (2003). Livelihoods and rural poverty reduction in Tanzania. *World Development*, *31*(8), 1367–1384.

Fávero, L. P. L., Belfiore, P., dos Santos, M. A., & Souza, R. F. (2020). Overdisp: A stata (and Mata) package for direct detection of overdispersion in poisson and negative binomial regression models. *Statistics, Optimization & Information Computing*, *8*(3), 773–789.

Frelat, R., Lopez-Ridaura, S., Giller, K. E., Herrero, M., Douxchamps, S., Djurfeldt, A. A., Erenstein, O., Henderson, B., Kassie, M., Paul, B. K., & Rigolot, C. (2016). Drivers of household food availability in sub-Saharan Africa based on big data from small farms. *Proceedings of the National Academy of Sciences*, *113*(2), 458–463.

Gautam, Y., & Andersen, P. (2016). Rural livelihood diversification and household well-being: Insights from Humla, Nepal. *Journal of Rural Studies*, *44*, 239–249.

Herfindahl, O. C. (1950). *Concentration in the US steel industry. Unpublished doctoral dissertation*, Columbia University.

Loison, S. A. (2019). Household livelihood diversification and gender: Panel evidence from rural Kenya. *Journal of Rural Studies*, *69*, 156–172.

Mbiba, M., Collinson, M., Hunter, L., & Twine, W. (2019). Social capital is subordinate to natural capital in buffering rural livelihoods from negative shocks: Insights from rural South Africa. *Journal of Rural Studies*, *65*, 12–21.

Michler, J. D., & Josephson, A. L. (2017). To specialize or diversify: Agricultural diversity and poverty dynamics in Ethiopia. *World Development*, *89*, 214–226.

Minot, N. ed. (2006). *Income diversification and poverty in the Northern Uplands of Vietnam* (Vol., 145). Intl Food Policy Res Inst.

Mitchell, S., Gelman, A., Ross, R., Chen, J., Bari, S., Huynh, U. K., Harris, M. W., Sachs, S. E., Stuart, E. A., Feller, A., & Makela, S. (2018). The Millennium Villages Project: A retrospective, observational, endline evaluation. *The Lancet Global Health*, *6*(5), e500–e513.

Mundlak, Y. (1978). On the pooling of time series and cross section data. *Econometrica: Journal of the Econometric Society*, 69–85.

Nagler, P., & Naudé, W. (2017). Non-farm entrepreneurship in rural sub-Saharan Africa: New empirical evidence. *Food Policy*, *67*, 175–191.

Nielsen, Ø. J., Rayamajhi, S., Uberhuaga, P., Meilby, H., & Smith-Hall, C. (2013). Quantifying rural livelihood strategies in developing countries using an activity choice approach. *Agricultural Economics*, *44*(1), 57–71.

Quandt, A. (2018). Measuring livelihood resilience: The household livelihood resilience approach (HLRA). *World Development*, *107*, 253–263.

Rahut, D. B., & Micevska Scharf, M. (2012). Livelihood diversification strategies in the Himalayas. *Australian Journal of Agricultural and Resource Economics*, *56*(4), 558–582.

Reardon, T., Delgado, C., & Matlon, P. (1992). Determinants and effects of income diversification amongst farm households in Burkina Faso. *The Journal of Development Studies*, *28*(2), 264–296.

Reardon, T. (1997). Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World Development*, *25*(5), 735–747.

Ricker-Gilbert, J., Jayne, T. S., & Chirwa, E. (2011). Subsidies and crowding out: A double-hurdle model of fertilizer demand in Malawi. *American Journal of Agricultural Economics*, *93*(1), 26–42.

Sanchez, P., Palm, C., Sachs, J., & Denning, G. (2007). The African millennium villages. *Proceedings of the National Academy of Sciences*, *104*, 16775–16780.

Scoones, I. (1998). Sustainable rural livelihoods: a framework for analysis. IDS Working Paper, issue 72 Retrieved from: https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/3390/Wp72.pdf?sequence=1

Simpson, E. H. (1949). Measurement of diversity. *Nature*, *163*(4148), 688–688.

Stackhouse, P. W. Jr, Zhang, T., Westberg, D., Barnett, A. J., Bristow, T., Macpherson, B., & Hoell, J. M. NASA POWER (Prediction of Worldwide Energy Resources). Release 8.01 (with GIS Applications) Methodology (Data Parameters, Sources, andamp; Validation). (2018). https://power.larc.nasa.gov

Tellegen, N. (1997). *Rural enterprises in Malawi: Necessity or opportunity?* Ashgate Publishing Ltd.

UN Millennium Project. (2005). *Investing in development: A practical plan to achieve the millennium development goals*. Retrieved from: https://digitallibrary.un.org/record/564468?ln=en

Waha, K., Van Wijk, M. T., Fritz, S., See, L., Thornton, P. K., Wichern, J., & Herrero, M. (2018). Agricultural diversification as an important strategy for achieving food security in Africa. *Global Change Biology*, *24*(8), 3390–3400.

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT Press.

Wooldridge, J. M. (2019). Correlated random effects models with unbalanced panels. *Journal of Econometrics*, *211*(1), 137–150.

Yang, Z., Hardin, J. W., & Addy, C. L. (2009). Testing overdispersion in the zero-inflated Poisson model. *Journal of Statistical Planning and Inference*, *139*(9), 3340–3353.

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