International Journal of
Economics Development Research, Volume 4(1), 2023
pp. 27-47

Livelihood Diversification And Household Vulnerability To Climate Shocks In Rural Kenya

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Abstract :

This study tests the hypothesis that livelihood diversification mitigates vulnerability to climate shocks among rural households in Kenya. The study is based on two waves of nationally-representative household survey data collected in 2005/06 and 2015/16. A measure of livelihood diversification in the sampled households was computed using Simpson Diversity Index. Comparison of means and correlation analysis was used to test the study's hypothesis on a sample of 8,483 and 12,217 rural households in 2005/06 and 2015/16 respectively. Consistent with the study's hypothesis, results indicate lower mean values of livelihood diversification indices for rural households that reported loss in welfare due to climate shocks compared to those that reported no adverse effects in both 2005/06 and 2015/16. Correlation analysis results indicate an inverse relationship between livelihood diversification and vulnerability to climate shocks for all sampled households. Distinctive and nuanced differences in results were found when analysis was disaggregated along income classes and agro-ecological zones. Sensitivity analysis confirmed robustness of the results. Based on these results, it is recommended that rural households be supported to pursue a diverse portfolio of income generating activities and assets in order to build resilience against climate shocks.

Keywords: Agro-Ecological Zones; Correlation Analysis; Resilience; Risk Management; Vulnerability

1. Introduction

Rural households in low-income economies usually pursue multiple income-generating activities rather than specialize in a single occupation in the agricultural and non-agricultural sectors (Ellis, 1998; Barrett, Reardon and Webb, 2001). Income from the non-farm activities accounts for 35 percent to 50 percent of household income in developing countries (World Bank, 2017). Rural households also maximize welfare by leveraging the spatial differences to optimize welfare returns through activities such as growing crops in different locations, migrating livestock in search of pastures and migration of household members to urban centres to seek for non-farm employment (Ellis, 1998). The process in which rural households build

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diverse portfolio of income generating activities as well as social support networks for the purpose of safeguarding and enhancing welfare constitutes the essence of livelihood diversification (Ellis, 1998).

Household participation in diverse portfolio of income generating activities is motivated mainly by the 'pull' and 'push' factors (Ellis, 1998; Asfaw et al., 2015; Nagler and Naudé, 2017). By 'pull factors', households are motivated to diversify based on opportunities available in their environment in order to increase incomes and enhance welfare. Households are also pushed into diversification in order to respond to various welfare-reducing shocks. Risk management, therefore, becomes the external stimuli that pushes households to expand their portfolio of livelihood support systems. As a risk-management strategy, households could use livelihood diversification ex-ante or ex-post. Households institute these strategies in order to smooth income from shocks (Baez, Kronick and Mason, 2013). Given that rural livelihoods in low-resource economies are characterized by frequent shocks, livelihood diversification is, therefore, an important strategy for stabilizing and smoothing consumption from the associated frequent and costly income fluctuations.

Since, in part, diversification entails pursuing a portfolio of unrelated livelihood options with low correlated returns, a perturbation in one source of livelihood need not result into a fall in household consumption because the other income streams (or livelihoods) are assumed to be unaffected by the same shock. Studies have found specific cases indicating that households with more diversified livelihoods report higher levels and more stable food consumption paths (Block and Web, 2001) while at the same time finding that diversified livelihood systems to have more resilience to stresses and shocks (De Haan, 2012). Livelihood diversification as a risk management strategy is commonly due to push factors and mostly works for the poor households seeking survival from income fluctuations. Essentially, livelihood diversification works as a risk management strategy because it provides a variety of livelihood options, reduces exposure as well as builds a buffer that protects household welfare from adverse effects of system perturbations (Marschke and Berkes, 2006).

Although livelihood diversification is a viable risk management strategy, not all households in low-resource economies are able to engage in it due to various hindrances. For example, given that most of rural livelihoods are land-based, unavailability, inadequacy and inaccessibility of land therefore hinders the extent of diversification (Ellis and Allison, 2004). In addition to land, rural households also require supporting infrastructure (such as rural roads, electricity, communication networks, markets, agricultural extension services) in order to pursue diversified livelihoods. Poverty is also a major impediment to livelihood diversification. Households without assets are limited in the extent of diversification (Organisation for Economic Co-operation and Development, 2007). Households without strong

social support networks are also less likely to diversify their livelihoods due to limited support and connections to access credit, capital, employment and other productive assets and opportunities.

2. Theoretical Background

Context of household livelihood diversification and vulnerability to shocks in Kenya

The Kenyan economy is spread in various sectors such as agriculture, manufacturing, building and construction, trading and services. According to Republic of Kenya (2019), the highest contributing sectors to the GDP and employment respectively were agriculture and natural resources (35 percent and 12.7 percent), manufacturing (7.7 percent and 11.1 percent), building and construction (5.4 percent and 6.2 percent), and trading and services (14.7 percent and 16.9 percent). The extent to which households generate livelihoods from these sectors depends on the specific sector's performance, level of human skills, entry and exit conditions and government policies. Accordingly, Kenyan households are likely to pursue a mixture of livelihoods from one or more of these sectors either concurrently, temporally or spatially (Nelson et al., 2016). Specific national policies and programmes have been implemented to enhance livelihood opportunities in all productive sectors of the economy. The livelihoods pursued are also depended on physical location (rural or urban, and according to agro-ecological zones), income and assets level, household education attainment levels, gender of household head, life-cycle of the productive household members, infrastructure and institutional support such as markets and extension services (McCord et al., 2015).

Majority of Kenyan households engage in their economic activities in the context of various climate shocks. Drought is a frequent phenomenon in arid and semi-arid lands (ASALs), which cover over 80 percent of the country's land mass and are home to 20 percent of the country's population (Republic of Kenya, 2012). Major droughts were experienced in 1998-2001, 2003/04, 2006, 2009, 2011, 2016/17 and 2019 (Fitzgibbon, 2012; UN Office for the Coordination of Humanitarian Affairs {UNOCHA}, 2019). The country also experiences destructive flooding in the river-basin areas of Tana River, Kisumu, Narok, Samburu, Turkana, Kilifi, Garissa, Mandera, Siaya, Homa Bay counties as well as in built parts of Nairobi city. Floods with severe adverse effects on household welfare occurred in 1961, 1963/64, 1968, 1977/78, 1982, 1985, 1990, El Niño floods of 1997/1998, 2003 and in 2015 (Kihiu and Laibuni, 2018). The 1997/1998 El Niño rains caused severe flooding, mudslides and disease outbreaks such as Rift Valley Fever (RVF), highland malaria and cholera in different parts of Kenya. The resultant flooding destroyed road, telecommunication and other civil networks, as well as reduced production of staples such as maize, potatoes and beans (Ngecu and Mathu, 1999). Kenya's maize

production, for instance, dropped by 20 per cent as a result of the El Nino (Wangia, Wangia, and De Groote, 2002).

Although the role of livelihood diversification in the management of general livelihood shocks is explored in the literature, the specific role of livelihood diversification in mitigating climate shocks in Kenya's economic and geographical context is not well known. Studies such as Dorsey (1999) McCord et al. (2015); Quandt, Neufeldt and McCabe (2017) have shown the association between various aspects of livelihood diversification and vulnerability to shocks. However, they are based on location-specific sample sizes and are therefore not representative of the heterogeneity in Kenyan rural households. Other studies such as Christiaensen and Subbarao (2005) and Mathenge and Tschirley (2015) used nationally representative sample sizes to show the effect of household off-farm labour diversification on vulnerability to climate and health shocks. However, rural livelihood diversification has other dimensions beyond alternative uses of household labour. These dimensions have potential influence on household vulnerability to livelihood shocks. This study seeks to contribute to the existing literature by analyzing two waves of nationally representative data to assess the association between rural livelihoods diversification and vulnerability to climate shocks in Kenya. The assessment of the association is also enriched by considering the household heterogeneity in agro-ecological zones and income levels. This disaggregation controls for the expected confounding effect of income and agro-climatic conditions in this relationship (Asfaw et al., 2019).

The role of livelihood diversification in household welfare outcomes is theoretically hinged upon the standard portfolio theory of risk and return as applied in finance. The essence of the theory is that economic agents are motivated to hold portfolios that maximize expected returns for given risk, as measured by its variance (Markowitz, 1959). Therefore, diversification can be regarded as an economic undertaking whose optimal value can be determined through marginal analysis of costs and benefits (Statman, 2004). Accordingly, households will seek a diverse portfolio of income generating activities if the marginal benefits of doing so exceeds the marginal costs (Statman, 2004). Costs of diversification, according to Statman (2004), are those related to transacting or holding into the activities, while the benefit is the reduction of risk, as measured by the standard deviation of portfolio returns.

The relationship between livelihood diversification and household vulnerability to shocks is theoretically explained on the basis of motives of holding a diverse portfolio for the purpose of risk management. Barrett, Reardon and Webb (2001) argue that there is a natural predisposition for livelihood diversification among rural households in developing economies due to: first, rural subsistence production has seasonal variations and therefore specialization would not result into the desired

smooth consumption across seasons. Secondly, diversification is motivated by the incomplete and missing markets for important factors of rural production such as land, labour, credit and insurance. Diversification also offers a means of ex-post coping with income shocks. Finally, diversification thrives because of existence of economies of scope – in which, unlike economies of scale – where concentration of production units results into greater output – more returns are obtained if production units are applied into multiple activities.

Previous Research Studies

Various empirical studies have examined the relationship between livelihood diversification and vulnerability to risks in low-income economies. Studies such as Abraha (2007), Mutenje et al. (2010), Asfaw et al. (2015), and Kubik and Maurel (2016) found that shocks trigger diversification, in which case the latter is a reactionary response to adverse effect of shocks. Other studies found that livelihood diversification enhances ex-ante adaptive capacity of households from adverse effects of shocks (Asfaw, Pallante and Palma, 2018). In other cases, no relationship was found between portfolio diversification and vulnerability to shocks (Kowalski et al., 2016; Dedehouanou and McPeak, 2020). Such findings have been attributed to the underlying characteristics of livelihood diversification and nature of shocks (such as portfolios being pro-cyclical or the intensity and severity of shocks). This study adds to the existing empirical works in Kenya such as Christiaensen and Subbarao (2005), Opiyo, Wasonga and Nyangito (2014) and Amwata, Nyariki, and Musimba (2016) on household vulnerability to climate-related shocks; McCord et al., (2015) on the finding that households diversify not solely for food security but also due to other reasons such as tradition or peer imitation; Lay, Mahmoud and M'Mukaria (2008), Olale and Henson (2013) and Romeo et al., (2016) on the effect of livelihood diversification on various aspects of household welfare such as nutrition, poverty and income distribution. To contribute to the existing literature on the welfare effects of climate shocks, this study uses a nationally representative sample size to assess the relationship between livelihood diversification and vulnerability to shocks but does not specify a priori the relationship between diversification and vulnerability to shocks as is the case with Mathenge and Tschirley (2015) who studied the effect of climate shocks on the labour market diversification in Kenya.

Based on the foregoing literature review, the study's hypothesis is formulated as; among rural households in Kenya, livelihoods diversification is negatively related with the vulnerability to climate shocks. In addition, it is hypothesized that household income levels and agro-ecological zones influence the relationship between livelihood diversification and vulnerability to climate shocks. Findings from this study are useful in formulating relevant policies for building rural household resilience, which is important in this era of increasing incidences of climate shocks.

3. Methodology

Theoretical Framework

The relationship between livelihood diversification and vulnerability to climate shocks is modelled under the broad theme of precautionary risk management. Since the primary motive of risk management is to ensure smooth consumption across different states, it is therefore expected that vulnerability to shocks is inversely related with the level and extent of livelihood diversification (Rampini and Viswanathan, 2016). Essentially, increasing the options in the portfolio of livelihood options leads to reduced risk in welfare fluctuations (Statman, 2004). In the context of this study and assuming incomplete markets as well as risk-averse households, diversification is considered as an insurance against welfare fluctuations brought by climate-related shocks (Rampini and Viswanathan, 2016). Livelihood diversification limits the negative impacts of climate shocks on household welfare by steadying incomes across different states. In addition, risks and opportunities for livelihood diversification differ across different categories of households, thus bringing a variation in this postulated relationship (Seaman et al., 2014).

Estimation Strategy

The relationship between livelihood diversification and vulnerability to climate shocks is estimated through correlation analysis. The premised relationship between the two has yielded the testable hypothesis that households with more diversified livelihoods are associated with fewer incidences of vulnerability to adverse effects of climate shocks. The postulated association is conditioned by the inclusion of agro-ecological zones and income classes of the sampled households, which are considered as important covariates with potential influence on the hypothesized relationship (Asfaw et al., 2019).

Climate shocks are assumed to be independent and identically distributed. These shocks are classified as covariate in nature, implying that their occurrence is non-discriminant of all households in the targeted physical location. However, the extent to which household welfare is adversely impacted by the shocks differs among the affected households on account of various factors such as the levels and extent of livelihood diversification. In this case, livelihood diversification can be seen as a response to climate shocks or alternatively, the extent to which households are vulnerable to shocks could be due to the level/extent of livelihood diversification (Paavola, 2008; Asfaw, Pallante and Palma, 2018).

Since it is possible that the variables considered in this study (livelihood diversification and vulnerability to climate shocks) can alternately be designated as explanatory as well as response variables, a regression analysis relating one variable as a function of the other could not be carried out in the scope of the data available. Instead, a correlation analysis describing the linear association between livelihood

diversification and vulnerability to climate shocks was implemented. The correlation results, indicating the strength and direction of the relationship, are adequate to answer the study's research questions. Since data on livelihood diversification and vulnerability to climate shocks were obtained from randomly selected samples of the population, inferences based on the findings of the correlation analysis are deemed valid (Ramsey and Schafer, 2012).

Computation of Livelihood Diversification Index

Rural households in Kenya draw their livelihoods mainly from agriculture and other natural resource endowments such as fishing, hunting and gathering. Non-agricultural sources of livelihood such as waged labour and trade also exist and their access depends on specific household and regional characteristics such as educational achievement, skills set and proximity to transport corridors or commercial nodes. According to literature, rural livelihoods' diversification consists of crop diversification, farm sector diversification (mixed farming), labour force diversification, income diversification, as well as social and institutional support networks (Ellis, 1998; Mehta, 2009). Crop diversification entails growing of different combinations of crops by households as a risk management strategy against climate and market-price shocks. Livestock diversification is the practice of keeping multi-species of livestock rather than only one specie, in order to spread livestock production risk. On the other hand, in mixed farming systems, crops are grown and livestock reared simultaneously to enhance food security, household income, conserve biodiversity and reduce vulnerability to shocks (Mekuria and Mekonnen, 2018). Labour force diversification entails engaging household productive members into varying and diverse income-generating activities (both on-farm and off-farm) so as to enhance and secure household incomes from fluctuations and hence build livelihood resilience to shocks. In the context of this study, income diversification entails the different sources of income available to households such as wage and non-wage (agricultural produce sales, non-farm enterprise earnings, transfers and miscellaneous sources). Finally, social and institutional support networks constitute the ties and associations – based on kinship, friendship, faith, traditions – that households rely upon to access assets, opportunities and coping options to shocks.

Computing livelihood diversification index for this study factored in all the possible sources of livelihood support of the sampled households, except for the contribution of social and institutional support networks due to lack of relevant data. Measuring the components of livelihood diversification at the household level assumes that the household optimizes allocation of its resources to the various livelihood generating sources, given its resource constraints (Mehta, 2009). This proposition, however, ignores the intra-household dynamics that can influence family economic activities (Anderson, Reynolds and Gugerty, 2017).

Crop diversification is measured by aggregating all the crop types grown as well as the different and separate pieces of land in which the crops are grown. To assess the extent of crop diversification, an index was first created combining a measure of income earned from crop sales and a measure of the type of crops grown (whether food or cash crops). To get an index measure of crop sales, the number of crops grown was multiplied by a correlation coefficient of crop sales and number of crops grown. An index measure of crop type grown (food or cash crops) was calculated as follows: since cash crops earn more than food crops, they were given a weight of one, while food crops a weight of zero. The weights were cumulated per household then multiplied with a correlation coefficient of crop sales and the aggregate crop-type weights. The two indices (sales from crops and types of crops grown) were aggregated to measure the extent of crop diversification.

Livestock diversification was measured by aggregating all livestock and poultry kept by the household. Household participation in non-agricultural income-generating enterprises was measured by the number of enterprises as shops, grain milling machines, rural furniture making, tailoring, water vending among others. Measurement per household was as follows: zero for no enterprise, one for one enterprise, 1.2 for two enterprises, 1.3 for three and 1.4 for four. Regarding other sources of income, households with such streams as rent, savings, interest, dividends and pensions were given a weight of one, and a zero to those that did not have such streams. Labour force diversification was measured by two indicators; aggregation of household members employed for pay either within or outside the household, and a measure of education attainment in the household. Levels of education qualification attained were weighted as follows: no formal schooling was weighted zero, primary level got a weight of one, secondary got 1.5, diploma level got 2, and finally graduate and post-graduate got a weight of 3. The total household education achievement was measured by the aggregation of individual members' attainment multiplied by the respective weights.

Livelihoods diversification index can be computed using various approaches. In one category of approaches, livelihood diversification is measured by the shares of livelihood sources within the total household livelihood portfolio (Asfaw et al., 2015; Lay, Mahmood and M'mukaria, 2008; Davis et al., 2010). Livelihood diversification indices based on shares include Margalef index, Herfindahl-Hirschmann index (HHI), ogive index and entropy index. In these measures, households with highly diversified livelihoods will have diversification index closer to one, while low livelihood diversification is indicated by an index closer to zero. This approach was not used in this study because the available data could not allow for the computation of livelihood shares from the different sources. An alternative approach to computing livelihood diversification index is through the computation of the number of livelihood sources and the relative proportion of the livelihoods from each source to the household portfolio (Mutenje et al., 2010; Addisu, 2017).

An example of this approach is the Simpson Diversity Index (SDI), which was used in this study as the available data could allow for its computation. In addition to the fact that SDI is simple, robust and widely applicable, it offers an alternative measure of diversification in cases where data does not allow for the computation of livelihood indices based on shares (Addisu, 2017). Therefore, as a measure of livelihood diversity, SDI considers the number of livelihood options present to a household as well as the relative abundance of each option (Mutenje et al., 2010). The SDI is calculated as

$$SDI = 1 - \sum_{i=1}^{n} W_i^2 \quad (1)$$

where, $$W_i = \frac{x_i}{\sum x_i} \quad (2)$$

x is the ith component of livelihood diversification and w is the proportionate measure of ith component in the total measure of livelihood diversification (Singh, Kumar and Singh, 2006). The calculated SDI ranges between zero and one, where zero represents no livelihood diversification while one represents infinite livelihood diversification.

Measure of Vulnerability to Climate Shocks

The climate shocks used in this study are drought and floods. Climate shocks by their nature manifest indiscriminately to almost all households within a community in which they occur. However, the extent to which occurrence of shocks translates into vulnerability depends on the specific household degree of exposure, sensitivity to the shock and the adaptive capacity (Adger, 2006). In this study, a household is categorized as vulnerable if it reported as having been severely affected negatively by drought and/or floods within a period of five years up to the time of data collection. Vulnerability to climate shocks is therefore a binary response variable, taking a value of one if a household reported being vulnerable and zero for an otherwise response.

Data Type and Sources

The study used two waves of household survey data collected in 2005/06 and 2015/16. The data was obtained from the Kenya Integrated Household Budget Surveys (KIHBS), which was administered by the national official statistics body, the Kenya National Bureau of Statistics (KNBS). Both surveys covered a period of twelve months in each data-collection period. Data was collected from 1,343 and 2,400 randomly selected sampling clusters in 2005/06 and 2015/16 respectively. In both periods, the clusters were generated from a nationally representative sampling frame known as National Sample Survey and Evaluation Programme (NASSEP). These sampling frames are normally used by KNBS to conduct household surveys in the country and comprise of randomly-sampled clusters drawn from enumeration areas of the censuses carried out in 1999 and 2009 (Republic of Kenya, 2007, 2018).

From the 1,343 clusters used in the 2005/06 KIHBS, 861 were rural and 482 urban. The 2015/16 KIHBS had 988 urban and 1,412 rural clusters sampled.
The sampling ended with the random selection of 10 households per the cluster sampled earlier, ultimately giving the total sample size in each wave accordingly. Only rural households were considered in this study because their livelihoods, derived mainly from agriculture, are most vulnerable to climate shocks. After an elaborate data cleaning process by both the KNBS and the authors, samples of 8,487 and 13,092 households in 2005/06 and 2015/16 respectively were used for analysis in this study. Sampled rural households were 8,483 and 12,217 in 2005/06 and 2015/16 respectively. From the rural households sampled, 2,808 and 4,018 – representing 36 percent and 31 percent in 2005/06 and 2015/16 respectively – reported being adversely affected by climate shocks

4. Empirical Findings/Result

Descriptive Statistics

The descriptive properties of the variables used in this study are presented in table 1. The mean value of livelihood diversification index was significantly higher in 2005/06 compared to 2015/16, significant difference in the two periods (p-value of 0.00). The differences arise first because fewer variables were used in the computation of the index in 2015/16 compared with the 2005/06 sample. For 2015/16 KIHBS, data contained in the agriculture (holding and output) and livestock modules had not been processed by the time of doing this study. Differences in the two datasets are also attributable to differences in the variables and measures used in the computation of livelihood diversification index (e.g. education variable). However, despite these differences, both are measures of livelihood diversification for rural households with higher values indicating more diversified livelihoods. The mean number of rural households which reported adverse effects of climate shocks on their welfare was lower in 2015/16 compared with 2005/06 (p-value of 0.00).

Table 1. Descriptive Statistics

	2005/06					2015/16				
Variables	**Mean**	**Std. Dev**	**Min**	**Max**	**N**	**Mean**	**Std. Dev**	**Min**	**Max**	**N**
Diversification index	0.617	0.171	0	0.828	8,483	0.323	0.260	0	0.75	12,217
Affected by drought/ floods	0.363	0.481	0	1	7,742	0.307	0.461	0	1	13,092
Variables contributing to livelihood d iversification index:										
Active labour size	2.780	1.518	0	16	8,484					
Education index	1.429	1.774	0	15.5	8,484	1.562	0.650	0	3.5	12,058
Number of farming plots	1.23	0.936	0	11	7,968					
Mixed cropping index	0.158	0.118	0.038	0.953	6,597					
Livestock types number	2.519	1.982	0	12	7,951					
Off-farm enterprises index	0.216	0.418	0	1.4	8,338					

Access to other income	0.101	0.302	0	1	8,324					
Household has nonfarm labour						0.575	0.494	0	1	13,092
No. of non-farm IGAs						0.195	0.447	0	4	13,092
No. of investment income sources						0.054	0.259	0	3	13,092

Source: Author's computation from KIHBS, 2005/06 and KIHBS, 2015/16

Diagnostic Tests

Before analyzing the relationship between livelihood diversification and vulnerability to climate shocks, various diagnostic tests were conducted to assess the validity of the measures used to represent this hypothesized relationship. First, consistent with literature, rural households had higher level of livelihood diversification in the 2005/06 data. Urban households had higher mean diversification index in 2015/16 data because the measure did not contain agriculture components due to unavailability of data. In addition, data indicate that rural households were most likely to report welfare losses from climate shocks compared to urban households. The variables were also tested for normality and homogeneity of variance. Although diversification index was found not to follow normal distribution in both data collection periods, the large sample sizes in both data sets allow a two-sample t-test to produce reliable results even with the violation of the assumption of normally – distributed populations (Kwak and Kim, 2017).

Association between Livelihood Diversification and Vulnerability to Climate Shocks

Comparison of Means

The main hypothesis being tested in this study is that households with more diversified livelihoods are associated with fewer incidences of vulnerability to adverse effects of climate shocks. First, the hypothesis is tested by comparing the mean values of livelihood diversification index across the households that reported vulnerability to climate shocks and those that did not. This was done using independent sample t-tests.

Table 2. Mean livelihood diversification index of vulnerable and non-vulnerable households: 2005/06

	Not Vulnerable			Vulnerable				
Household category	N	Mean	Std Dev	N	Mean	Std Dev	Diff(mean)	t-value
All rural	4,933	0.634	0.156	2,808	0.602	0.172	0.033	8.502***
Poor rural	1,994	0.617	0.167	1,611	0.566	0.192	0.050	8.388***
Non-poor rural	2,939	0.646	0.146	1,197	0.649	0.127	-0.003	-0.633
Rural ASALs	792	0.573	0.189	1,428	0.551	0.202	0.022	2.458**
Rural non-ASALs	4,141	0.646	0.146	1,380	0.654	0.112	-0.008	-1.819*

***, **, *: significant at 1%, 5% and 10% respectively

Source : Data Processed (2021)

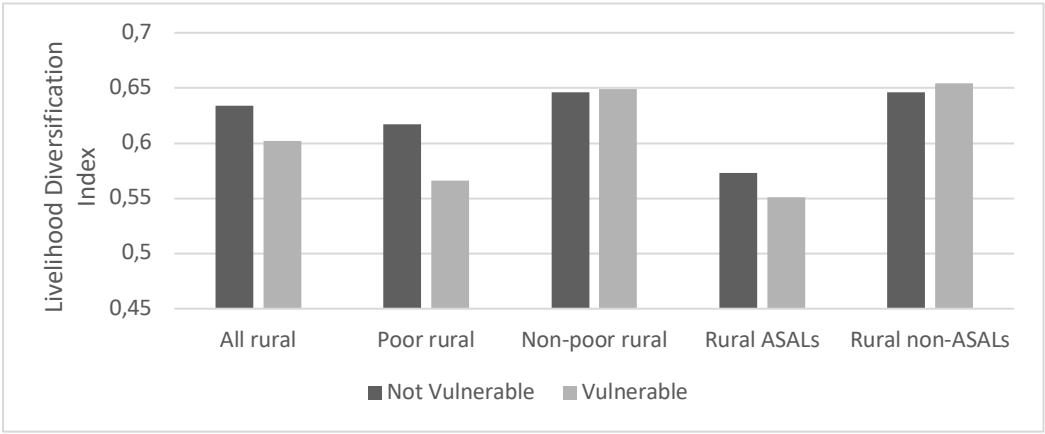

Figure 1, Mean livelihood diversification index of vulnerable and non-vulnerable households: 2005/06

Source : Data Processed (2021)

The 2005/06 data indicates non-vulnerable households having higher livelihood diversification index for the aggregated sample. Disaggregation of the data revealed unique differences in the mean livelihood diversification indices between the vulnerable and non-vulnerable households. In the non-ASALs, households with higher level of livelihood diversification reported higher likelihood of vulnerability from climate shocks.

Table 3. Mean livelihood diversification index of vulnerable and non-vulnerable households: 2015/16

	Not Vulnerable			Vulnerable				
Household category	N	Mean	Std Dev	N	Mean	Std Dev	Diff(mean)	t-value
All rural	8,519	0.339	0.254	3,698	0.287	0.268	0.052	10.161***
Poor rural	2,729	0.304	0.257	1,623	0.248	0.264	0.056	6.827***
Non-poor rural	5,790	0.356	0.251	2,075	0.318	0.267	0.038	5.781***
Rural ASALs	2,258	0.310	0.268	1,781	0.270	0.268	0.041	4.775***
Rural non-ASALs	6,261	0.349	0.248	1,917	0.304	0.267	0.046	6.923***

***, **, *: significant at 1%, 5% and 10% respectively

Source : Data Processed (2021)

Consistent with the study's hypothesis, results indicate lower mean values for rural households that reported loss in welfare due to climate shocks compared to those that reported no adverse effects in both 2005/06 and 2015/16. The mean values were also compared in disaggregated samples to control for the effect of income and climatic differences on the relationship between livelihood diversification and vulnerability to climate shocks. Households with monthly per adult equivalent total expenditure of KES. 1,562 and below were classified below the national absolute poverty line. Additionally, households were classified into two agro-ecological zones (AEZ); those from arid and semi-arid lands (ASALs) and those from the non-ASAL zones suitable for agricultural production. The district from where the household is sampled from was the lowest unit of AEZ classification in 2005/06

while the county was the reference in the 2015/16 dataset. Interpretation of results should consider the view that the classification of households into AEZ based on districts and counties is greatly generalized, since there are cases of districts and counties in Kenya with different agro-climatic conditions and it is possible that the sampled households from same district or county do not share similar AEZ characteristics.

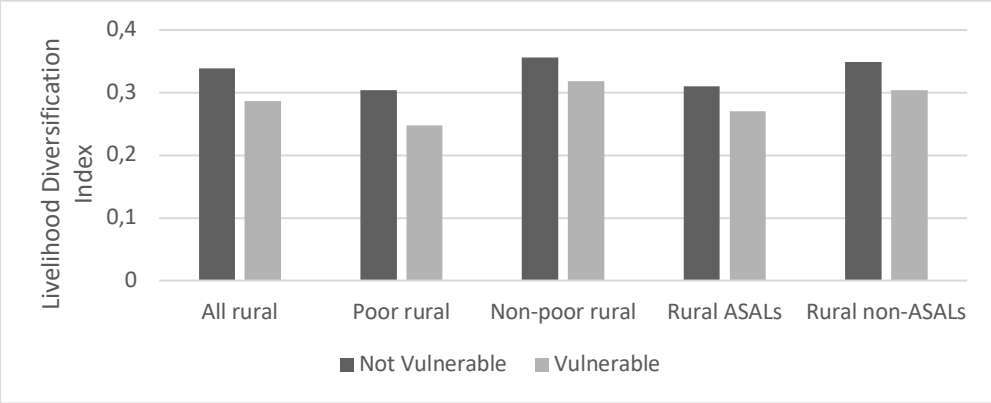

Figure 2: Mean livelihood diversification index of vulnerable and non-vulnerable households: 2015/16

Source : Data Processed (2021)

Results indicate that for households below the poverty line, vulnerability to climate shocks was significantly higher in less diversified households in both survey periods. However the results were indeterminate in households above the poverty line in 2005/06. In the ASALs, vulnerable households had lesser diverse livelihoods in both survey periods, although the difference was lower in 2005/06. For households in non-ASAL zones, a similar pattern as in ASALs was observed in 2015/16 data, while the 2005/06 data shows the vulnerable households having more diverse livelihoods. It is important to note that this finding is only statistically significant at 10 percent level of significant, indicating a high likelihood of attributing it to chance.

Correlation Analysis

The study's hypothesis that a higher livelihood diversification is associated with less vulnerability to climate shocks is further tested by conducting a correlation analysis between the two variables using a point-biserial correlation analysis. This analysis is used because livelihood diversification index is a continuous variable and household vulnerability to climate shocks is a binary variable. Point-biserial correlation is a special case of measuring the association between one random variable which is continuous/metric and another random variable which is binary (Tate, 1954). The categories in the binary variable do not have a natural ordering, indicating that the coding of categories of the binary variable as zero or one is just arbitrary. The

calculated correlation coefficient can take a value of +1 (indicating perfect positive association), zero (no association at all) and -1 (indicating perfect inverse association) (Kornbrot, 2005).

Table 4. Point biserial correlation coefficient between livelihood diversification and vulnerability to climate shocks 2005/06

Household category	Point-biserial correlation coefficient	t-value	P>|t|	N
All rural	-0.0962	-8.5017	0.000	7,741
Poor rural	-0.1384	-8.3872	0.000	3,605
Non-poor rural	0.0098	0.6326	0.527	4,136
Rural ASALs	-0.0521	-2.4572	0.014	2,220
Rural non-ASALs	0.0245	1.8187	0.069	5,521

Source : Data Processed (2021)

Correlation analysis results using the 2005/06 data (table 4) indicate an inverse relationship between livelihood diversification and vulnerability to climate shocks for all sampled households and the rural households below the poverty line. Correlation coefficients of approximately -0.1 and statistically significant at one percent level of significance are observed, indicating that a weak relationship exists between the two variables. This implies that although the association is weak, it is not out of chance. In addition, the results indicate that, perhaps, livelihood diversification in rural areas of Kenya shields households from adverse effects of climate shocks, but it is not adequate. A study in Uganda (Goulden et al., 2013) also found limitations of livelihood diversification strategies in building household resilience from climate shocks. In addition, the limitations in the data earlier highlighted, including the measurement of vulnerability to climate shocks could be clouding the actual strength of the association. Generally, these results are in agreement with other studies that found inverse relationship between diversification and vulnerability to climate shocks (Christiaensen and Subbarao, 2005; Amwata, Nyariki, and Musimba, 2016).

Table 5. Point biserial correlation coefficient between livelihood diversification and vulnerability to climate shocks 2015/16

Household category	Point-biserial correlation coefficient	t-value	P>|t|	N
All rural	-0.0915	-10.1608	0.000	12,217
Poor rural	-0.1029	-6.8262	0.000	4,352
Non-poor rural	-0.0650	-5.7802	0.000	7,865
Rural ASALs	-0.0749	-4.7748	0.000	4,039
Rural non-ASALs	-0.0763	-6.9221	0.000	8,178

Source : Data Processed (2021)

For non-poor households (those above the poverty line), livelihood diversification did not appear to have a statistically significant association with the vulnerability to climate shocks. This finding confirms the proposition that accounting for household income status is important in determining the actual relationship between livelihood

diversification and vulnerability to climate shocks. Specifically, the results show that unlike the case of poor households, vulnerability to climate shocks is not associated with the level of livelihood diversification among the non-poor households. For the poor on the other hand, keeping a diverse portfolio of income generating activities was associated with less likelihood of reporting adverse effects of climate shocks.

Distinctively different results were also observed when the influence of households' agro-ecological conditions was considered. In the ASALs, the 2005/06 data indicate that more livelihood diversification was associated with less vulnerability to climate shocks, although the coefficient was lower and weaker in terms of statistical significance, as compared with the aggregated sample of all rural households. On the other hand, in non-ASALs, livelihood diversification was associated with more vulnerability to climate shocks, although the association is weak (correlation coefficient of 0.02) and statistically significant only if the level of significance is expanded to 10 percent. This implies that the direct relationship between livelihood diversification and vulnerability to climate shocks for households in high potential areas is mainly due to chance and could not be interpreted further. Since the incidences of climate shocks are higher in ASALs than in high potential areas, it is expected that households in ASALs will most likely pursue diverse livelihoods for welfare risk mitigation rather than for wealth accumulation, which is expected to be the main driver of diversification in high potential zones. Therefore, while the mean levels of livelihood diversification are lesser in ASALs' households than in their counterparts in non-ASALs (partly due to comparatively fewer opportunities for diversification), such diversification is most likely associated with lesser vulnerability to climate shocks. Correlation results validate this presumption in the case of 2005/06 data. The role of agro-ecological location and wealth status of households in moderating the relationship between livelihood diversification and vulnerability to climate shocks was also established in rural Zambia (Arslan et al., 2018).

Results using the 2015/16 data (presented in table 5) reveal an inverse and statistically significant relationship between livelihood diversification and vulnerability to climate shocks, a finding that supports the study's hypothesis. The results are also consistent with regression results obtained by (Christiaensen and Subbarao, 2005; Amwata, Nyariki, and Musimba, 2016) in the Kenyan context. The relationship is stronger for the aggregated rural sample and for the households below the poverty line. Significant differences in the hypothesized relationship are noted when households are disaggregated along income status, and less significant when disaggregation is considered along agro-ecological zones. The results based on the 2015/16 data should be interpreted with caution considering that data on agriculture-related livelihoods was not included in the computation of the diversification index. This omission likely affects the results given that agriculture constitute a significant contribution in the livelihoods of rural households in Kenya.

5. Discussion

Before drawing conclusions and making policy recommendations based on this study's findings, sensitivity analyses were carried out to assess the robustness of the results generated. The effect of outliers on the results were assessed by varying the percentage of left-leaning observations excluded in the analysis (the distribution of livelihood diversification index is skewed to the left). In the 2005/06 data, results only changed when 31 percent of outlying observations were omitted from analysis, while change using 2015/16 data was noted after 28 percent of outlying observations were excluded. Upon changing the method of analysis from correlation to regression, similar results as in correlation analysis (direction of relationship and p-value) were obtained using regression analysis on assumption of either direction in the relationship between vulnerability to climate shocks and the level of livelihood diversification.

Also tested were the differences in mean values of livelihood diversification index between households affected by climate shocks and those not affected using a non-parametric test – the Wilcoxon–Mann–Whitney test. The results gotten were similar – in terms of p-values – to those produced by the parametric t-test for both datasets. When the urban households were included in the analysis, the results changed implying that rural households were more vulnerable to climate shocks. Finally, correlation analysis (using 2005/06 data) between livelihood diversification index and other shocks revealed food-price shocks, water shortage, livestock deaths had similar relationship as in climate shocks. This is plausible since climate shocks have similarities with food-price inflation, water shortage and livestock deaths. Shocks such as non-agricultural business failure, large fall in sale prices for crops, and large rise in agricultural input prices had a relationship with livelihood diversification that is opposite the relationship that livelihood diversification had with climate shocks. This is expected since households adversely effected by such shocks are most likely to have higher levels of livelihood diversification. In addition, as expected, other shocks such as birth in the household, incarceration of a household member, destruction of dwellings and HIV/AIDS affliction were found not to have significant association with livelihood diversification

6. Conclusions

Using two waves of nationally-representative data, this study examined the relationship between livelihood diversification and vulnerability to climate shocks among rural households in Kenya. Past research was reviewed to contextualize the study within the body of literature and to provide theoretical and empirical basis for hypothesis testing. In both datasets, results support the study's hypothesis that households with higher livelihood diversification index were less likely to be

vulnerable to climate shocks. Disaggregating the data revealed variations in the results across income classes and agro-ecological zones. Sensitivity analyses found the estimation models and results to be robust and therefore valid for policy inferences.

These findings support recommending promotion of a diverse portfolio of income generating activities and assets as an important strategy for building rural livelihoods' resilience against climate shocks. The government can achieve this through equipping vulnerable households with necessary skills and providing them with opportunities to diversify their livelihoods. Specific interventions include promoting education and health access to build human capital as well as building physical infrastructure to enhance commerce and growth of exchange economy. In the arid and semi-arid areas of the country, diversification can be promoted through innovations along the existing livelihoods such as value addition in livestock products, livestock feeds (e.g. hay and fodder making) and marketing opportunities for livestock products. Finally, in line with the principles of Sustainable Development Goals, economic growth and development policies for rural areas should be designed with the objective of reducing pressure on natural resources which subsequently reduces the frequency and incidences of climate shocks.

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