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Effects of adaptation to rainfall variability on livelihood vulnerability of crop farming households in semi-arid lands: a case of Kitui south sub-county, Kenya

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ABSTRACT

Rainfall variability has adverse effects on livelihoods of rain-fed crop farming households. However, the role of adaptation in reducing this vulnerability has not been well documented. The objective of this study was to contribute to understanding the effects of adaptation to rainfall variability on households' livelihood vulnerability. A questionnaire was used to collect household data for analysis. Livelihood Vulnerability Index (LVI) was calculated for each household. Adaptation strategies to rainfall variability used by the households in the study area were identified and regression analysis, $LVI = \beta_0 + \beta_1 + \beta_2 + \ldots\ldots + \varepsilon$, used to establish significance of the adaptation to rainfall variability on households' livelihood vulnerability. The study established that despite households using many adaptation strategies, this did not contribute significantly to reduction of their levels of livelihood vulnerability ($p=0.2076$). The study concludes that differences in livelihood vulnerability among households in the study area can be attributed to variations in socio-economic factors and therefore adaptation alone is not sufficient in reducing households' vulnerability to rainfall variability. The study recommends the need of addressing socio-economic factors which contribute to high levels of LVI among households as intervention measures to effects of rainfall variability in dry lands.

Introduction

Rain-fed farming is practiced in about 80% of the world agricultural lands (Steduto *et al.,* 2012). In arid and semi-arid lands (ASALs) rainfall variability causes long periods of within-season dry spells which negatively affects livelihoods of many rural inhabitants especially farmers who largely rely on rainfall (Macharia *et al.,* 2012). Agriculture is expected to produce 60% of food by the year 2050 to feed the ever-increasing world

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population (Alexandratos & Bruinsma, 2012). The increase in food production is, however, faced by challenges of impacts to climate change and variability (Dinesh *et al.*, 2017). Several studies on how climate change and variability, aggravated by greenhouse gases emissions, affects various ecosystems have been carried out (Deressa *et al.*, 2008; Dhaka *et al.*, 2010; Gbetibouo, 2009; Intergovernmental Panel on Climate Change [IPCC], 2007a; IPCC, 2007b; Yesuf *et al.*, 2008). Most of these studies suggest a number of adaptation measures that can be used to reduce livelihood vulnerability to rainfall variability. These includes: access and use of seasonal rainfall forecasts, use of early maturing crop varieties, water conservation techniques, change in timing of farm activities, soil conservation measures, mulching, crop rotation, intercropping, harvesting of rain water, zero tillage, growing of drought tolerant crop varieties, agro-forestry, irrigation, crop diversification, migration and engaging in non-farm activities.

In areas where agricultural productivity is low and measures of coping with the effects of climate change and variability are limited, productivity is expected to reduce even to lower levels (Food and Agriculture Organization [FAO], 2010). This will make rain-fed crop farmers to be more vulnerable to rainfall variability. In order to have high agricultural productivity, farming system must become more resilient to adverse climate events. This requires elaborate and deliberate transformation especially in the smallholder agricultural systems in order to achieve food security (Bruinsma, 2009). This can be achieved through appropriate adaptation strategies to rainfall variability aimed at promoting resilience and lowering livelihood vulnerability to rainfall variability especially among the rural poor.

Adaptation aims at moderating the adverse effects of unavoidable climate change and variability by taking action to seize opportunities brought about by such changes and variations (Sithole & Murewi, 2009). This has overall aim of reducing livelihood vulnerability among farming communities. Adaptation to climate change and variability has great challenges as it is difficult to monitor and its effectiveness is less certain (Fussel & Klein, 2006). This means that poor countries will continue to be impacted by effects of climate change and variability if appropriate adaptation measures are not used (FAO, 2013; Hansen *et al.*, 2007) making them more vulnerable. However, with appropriate and timely adaptation strategies, livelihood vulnerability can greatly be reduced. During the 2017 world convention on sustainable development goals, there was consensus that adaptation to climate change and variability should be prioritized in the agricultural sector in order to achieve global food security and reduce livelihood vulnerability (United Nations Framework Convention on Climate Change [UNFCCC], 2017). This paper examines the role of adaptation in reducing livelihood vulnerability to rainfall variability among crop farming households in semi-arid Kitui South sub-County in Kenya.

Literature Review

As agriculture is expected to produce 60% food by the year 2050 to feed the ever-increasing world population (Alexandratos and Bruinsma, 2012). Increase in food production is faced by challenges of impacts to climate change and variability (Dinesh *et al.*, 2017). In order to increase food production to feed the world population, farm management practices should be guided by prevailing and anticipated climate conditions in any given area. Proper vulnerability mapping and monitoring is therefore important in guiding farmers in making appropriate agricultural household level decisions.

Studies on how climate change and variability affect various ecosystem show that adaptation measures can be used to reduce livelihood vulnerability to rainfall variability. These strategies spread the risks involved and are geared towards mitigating the negative effects of poor seasons but sometimes fail to exploit the favourable opportunities of average seasons (Cooper *et al.,* 2008). Sultan *et al.*, (2005) found out that adapting to rainfall variability is a recommendable way of realizing sustainable agricultural productivity for communities depending on rain-fed agriculture as humans cannot stop rainfall variability. This is important in reducing livelihood vulnerability to rainfall variability among these communities. Rain-fed crop production will remain the main source of staple food and foundation of livelihood for most of the rural poor in Sub-Saharan Africa (Ngaira & Musiambo, 2012). Proper investment in approaches to reduce effects of the variable climatic conditions such as rainfall variability is therefore important. The ability of crop farmers and agricultural stakeholders in general in Sub-Saharan Africa to cope better with the challenges and opportunities of current climate variability must be promoted so as to reduce livelihood vulnerability (Cooper *et al.*, 2008). The most effective ways to mitigate consequences of climate variability is to increase agricultural growth and development. The livelihood assets that affect one's adaptive capacity include: natural capital, socio-political capital, human capital, physical capital and financial capital. The stronger, more resilient and more varied the asset base of a household, the greater it's adaptive ability and level of sustainability of their livelihoods.

The Adaptation Consortium (ADA), a four-year Department for International Development (DFID) funded initiative, has been in the forefront in promoting resilience to climate change and variability in Kenya. The consortium provides practical tested models and experience aimed at promoting adaptation at county level (ADA, 2017). This has great benefits as it is downscaled to various counties and therefore there is likelihood that it can be practiced at farm level. In Kenya, the consortium started in five counties: Kitui, Makueni, Garissa, Isiolo and Wajir, with aim of replicating the achieved strategies throughout the ASALs in Kenya. It is funded under the Strengthening Adaptation and Resilience to Climate Change in Kenya Plus and enables the county governments to access climate finance fund in support of global adaptation and climate resilience development. County Climate Change Funds (CCCFs) have been established to support and implement community-prioritized intervention towards climate resilient development (Murphy & Orindi, 2017). Climate change planning committees have been established at both county and ward levels to prioritize investment aimed at promoting resilience to climate change and reduce livelihood vulnerability among farmers.

More case-focused studies need to be conducted so as to reduce blanket generalizations and mitigation measures associated with regional and global assessments of the impacts of climate change and variability on crop farming. This will give uncontested contribution of adaptation to reduction of livelihood vulnerability to rainfall variability. There is, therefore, need to identify farm-level effects of adaptation to rainfall variability on livelihood vulnerability in semi-arid areas such as Kitui South

Methodology

Description of the study area

Kitui South sub-County (Figure 1) lies between latitudes 1°35'S and 3°04'S and longitudes 38°31'E and 38°58'E. It borders Makueni County to the West, Tana River County to the East, Kitui Rural and Kitui East sub-Counties to the North and Taita Taveta County to the South. It covers an area of 12,834.72 square kilometers including part of Tsavo East National Park which an area of 6,302.7 square kilometers. The area is generally lowland and experiences a bimodal rainfall regime with an average annual amount of about 600mm (RoK, 2013). The long rains are received between March and May with a peak in April while the short rains are received from October to December. However, the short rains are more reliable in terms of amount and distribution as compared to long rains which in many years fail completely. Temperature ranges between 18°C and 34°C.

According to Jaetzold *et al.* (2007), Kitui South sub-County has four main agro-ecological zones (AEZ's) namely: Lower Midland 4 (LM4), Lower Midland 5 (LM5), Inner Lowland 5 (IL5) and Inner Lowland 6 (IL6). However, there are a few patches of Upper Midland 3-4 (UM3-4) and Upper Midland 4 (UM4) at the high areas of the Yatta plateau, Lower Midland 3 (LM3) comprising of steep slopes around the central plateau and Lower Midland 6 (LM6) forming a small dry area in Mutha Division. Crop farming is mainly practiced in three AEZs – LM4, LM5 and IL5. Agro-ecological zone IL6 receives very little or no rainfall in most of years. Over 87% of the households in the study area derive their livelihoods from subsistence agriculture with main crops grown being maize, beans, sorghum, millet, green grams, cowpeas and pigeon peas (RoK, 2013).

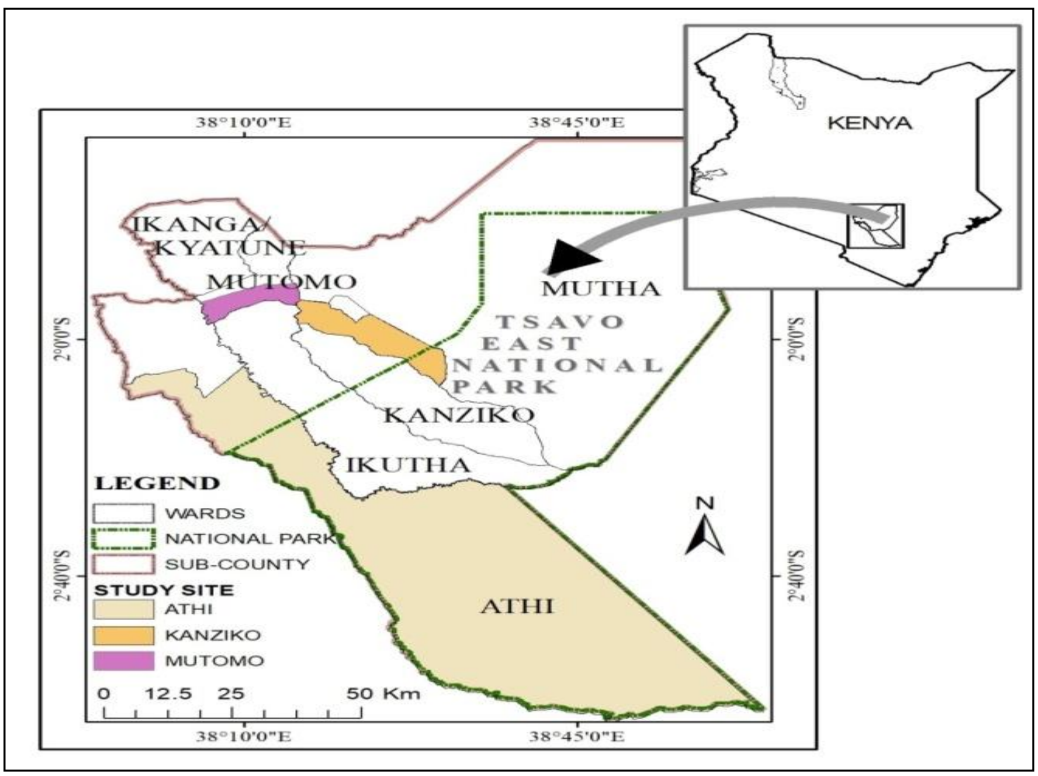

Figure 1: Map showing the study area

Source: Modified from IEBC, 2012

Sampling

Kitui South sub-County was purposively picked due to its dominance in rain-fed agricultural activities, high variability of rainfall and the numerous adaptation efforts made by the households in the area. Multi-stage sampling technique was used. In stage one, cluster sampling was used to obtain the administrative divisions and households to be used in the study. All the six administrative divisions in the sub-County were listed and clustered based on various agro-ecological zones (Low Midland 4, Low Midland 5, Inner Lowland 5, Inner Lowland 6, Upper Midland 3-4 and Upper Midland 4). In stage two, purposive sampling was used to select three study sites. Out of the six administrative divisions in the sub-County, three (Athi, Mutomo and Kanziko) were purposively sampled to represent the three main agro-ecological zones, LM5, LM4 and IL5, where crop farming is dominant. Three administrative locations, one from each division, were also purposively picked. This was based on proximity to administrative centres of the divisions for institutional support. These were Mutomo location (in Mutomo Division), Athi location (in Athi Division) and Kanziko location (in Kanziko Division). According to 2009 Kenya's Population and Housing Census results, the study area (the three locations) had 3,409 households (Kenya National Bureau of Statistics [KNBS], 2010). A list of all heads of households engaged in crop farming was obtained from the Chief's office of each location to form the sample frame. Stratified and random sampling techniques were used to obtain a sample of 311 households as follows: 102 households from Mutomo Location, 113 households from Athi Location and 96 households from Kanziku Location. Livelihood Vulnerability Index (LVI) for each household was calculated using Inter-governmental Panel for Climate Change (IPCC) framework (LVI = E – AC x S) which ranges from -1 (not vulnerable) to +1 (extremely vulnerable).

Data Sources and Analysis

Two major sources of data were used, namely primary and secondary data. Primary sources included responses from 311 closed-ended and open-ended questionnaires administered to randomly selected households' heads in Kitui South sub-County. The questionnaires were used to obtain information on demographic characteristics, factors contributing to vulnerability to rainfall variability and adaptation strategies used by households in the study area. An interview guide was used to collect data from key informants. A total of ten key informant interviews were conducted targeting County Agriculture Director, Kenya Meteorological Department, agricultural extension officers, non-governmental organizations (NGOs), local government administrators and community elders. This was aimed at obtaining supplementary information on vulnerability among households as well as the activities they engage in promoting adaptation as a way of reducing effects of rainfall variability in the study area.

Livelihood vulnerability index (LVI) was calculated using IPCC-LVI framework (LVI = (e – a) x s) to establish variations in levels of vulnerability to rainfall variability among households and was scaled from negative one (-1) to positive one (1). The variables for calculating vulnerability index were estimated using Hahn *et al.* (2009) method. The three contributing factors to vulnerability (exposure, sensitivity and adaptive capacity) were used in the study (IPCC, 2014). Each household was assigned was its LVI value and the mean LVI value for the study area established. Table 1 shows the contributing factors to vulnerability as conceptualized in this study.

Table 1: Components of LVI Analysis

Factor	Component	Sub-components (variables for analysis)
Exposure	Seasonal rainfall variability	• Onset of seasonal rainfall • Cessation of seasonal rainfall • Within-season dry spell • Seasonal mean rainfall
Sensitivity	Food security status	• Number of months a household goes without three meals per day in a year • Availability of seeds for next planting season • Availability of stock of harvest to last up to the next harvesting time
Adaptive capacity	Socio-demographic profile	• Education level of household heads • Gender of household heads
	Livelihood strategies	• Availability of off-farm income • Availability of surplus income
	Social networks	• Access to early warning seasonal climate information • Access to relief food

Source: *Author, 2019*

The study used index-based approach to measure levels of vulnerability. A balanced weighted average approach was used where each sub-component have equal contribution to the overall LVI value (Hahn *et al.*, 2009). Since each sub-component is measured on a different scale, the formula (Equation 3) was used to transform the scores to unitary values:

$tV_{sb} = (S_b - S_{min}) \div (S_{max} - S_{min}$

Where;

tV_{sb} is the transformed value of a sub-component

S_b is the value obtained for the sub-component

S_{min} is the minimum value for the sub-component

S_{max} is maximum value for the sub-component.

The transformed values lie between (0) and 1 (one). Values for the contributing factors to vulnerability (exposure, sensitivity and adaptive capacity) were calculated by obtaining average of the values of the transformed sub-components of each factor. The Livelihood Vulnerability Index for each household was then calculated using IPCC-LVI framework.

$LVI = (e - a) \times s$

Where;

e is the transformed index for exposure

a is the transformed index for adaptive capacity

s is the transformed index for sensitivity.

Multiple linear regression of LVI score on adaptation to rainfall variability was done to analyze the effects of adaptation to rainfall variability on households' livelihood vulnerability. Twenty commonly used adaptation strategies to rainfall variability were analyzed. These were growing drought tolerant crops, staggered planting, intercropping, irrigation, zero tillage, growing short-duration crops, agro-forestry, taking crop insurance, fallow farming and rain water harvesting. Others were off-farm employment, remittance from family members, mulching, crop rotation, mixed farming, reducing land under crops, participating in food-for-work, developing water sources, selling land to buy food and migrating to areas not affected by rainfall variability.

Results and Discussions

LVI for each household was calculated from household data on exposure, sensitivity and adaptive capacity and scored between negative one (-1) and one (1). This is shown in Table 2.

Table 2: Raw LVI Scores for Households (N=311)

N	Minimum	Maximum	Mean	Std. Deviation
311	-0.40	0.34	0.0454	.06767

Source: *Survey Data, 2019*

The minimum households' LVI score in the study area was established to be -0.40 while the maximum score was 0.34. The mean LVI score was 0.045, an indication that households in the study area were generally vulnerable to rainfall variability. Results on strategies used by households towards adaptation to rainfall variability and rate of use in the previous three years prior the study (Table 3) indicated that all households were growing drought tolerant crop varieties as a strategy to adaptation to rainfall variability. On the other hand, no households practiced zero tillage, sold land to buy food or migrated to areas not affected by rainfall variability. This could be attributed to the fact that many households do not consider these as adaptation strategies to climate change and variability (FAO, 2010). The strategies that recorded highest usage by the households (over 70%) were intercropping, growing short duration crop varieties and mixed farming. Strategies which had lowest usage (below 30%) were irrigation, agro-forestry, taking up crop insurance, fallow cultivation, mulching and developing water sources for supplementary irrigation.

Table 3: Adaptation to Rainfall Variability

	Number of Years Used			
Strategy	0	1	2	3
Growing drought tolerant crops	-	-	-	100%
Staggering crop planting	45.3%	10.3%	2.6%	41.8%
Intercropping	10.6%	-	-	89.4%

Irrigation to unaffected areas	96.5%	2.2%	-	1.3%
Zero tillage farming	100%	-	-	-
Growing short-duration crops	25.1%	-	1.3%	73.6%
Agro-forestry	96.1%	-	-	3.9%
Taking crop insurance	95.5%	0.6%	2.9%	1.0%
Fallow farming	83.3%	16.4%	0.3%	-
Rain harvest	53.4%	-	-	46.5%
Employment	35.0%	-	-	65.0%
Relying on family remittances	66.2%	1.3%	-	32.5%
Mulching	75.9%	-	-	24.1%
Crop rotation	89.1%	-	-	10.9%
Mixed farming	18.6%	-	-	81.4%
Reducing land under crop farming	48.6%	1.3%	1.3%	48.9%
Engaging in work for food	53.1%	9.3%	2.6%	35.0%
Establishing water sources	85.5%	-	-	14.5%
Selling land to buy food	100%	-	-	-
Migrating to unaffected areas	100%	-	-	-

Source: Author, 2019

Major adaptation strategies used by most households for three years were cross-tabulated with some of their socio-economic characteristics (location, gender, age of household head and education level). These strategies were planting drought tolerant crops, inter-cropping, planting short duration crops, seeking off-farm employment and practicing mixed farming. This was to show percentage distribution of the major adaptation strategies by the socio-economic characteristics. The results are shown in Table 4.

Table 4: Main Adaptation Strategies and Socio-economic Characteristics

	Adaptation strategy				
Socio-economic characteristics	**Growing drought tolerant**	**Inter-cropping**	**Short-duration crops**	**Seeking off-farm employment**	**Mixed farming**

Gender	Female	108 (34.7%)	183 (58.8%)	76 (24.4%)	63 (20.3%)	85 (27.3%)
	Male	203 (65.3%)	95 (30.5%)	153 (49.2%)	139 (44.7%)	168 (54.0%)
Age	< 35 years	29 (9.3%)	27 (8.7%)	18 (5.8%)	16 (5.1%)	20 (6.4%)
	36 – 50	127 (40.8%)	127 (40.8%)	95 (30.5%)	85 (27.3%)	106 (34.1%)
	51 – 65	88 (28.3%)	88 (28.3%)	65 (20.9%)	53 (17.0%)	76 (24.4%)
	Over 65	67 (21.5%)	67 (21.5%)	51 (16.4%)	48 (15.4%)	51 (16.4%)
Location	Mutomo	102 (32.8%)	85 (27.3%)	90 (28.9%)	96 (30.9%)	98 (31.5%)
	Kanziku	113 (36.3%)	103 (33.1%)	69 (22.2%)	30 (9.6%)	91 (29.3%)
	Athi	96 (30.9%)	90 (28.9%)	70 (22.5%)	76 (24.4%)	64 (20.6%)
Education level	Non formal	67 (21.5%)	58 (18.6%)	49 (15.8%)	51 (16.4%)	52 (16.7%)
	Primary	179 (57.6%)	161 (51.8%)	138 (44.4%)	115 (37.0%)	148 (47.6%)
	Secondary	48 (15.4%)	44 (14.1%)	31 (10.0%)	26 (8.4%)	41 (13.2%)
	Tertiary	17 (5.5%)	15 (4.8%)	11 (3.5%)	10 (3.3%)	12 (3.9%)

Source: *Author, 2019*

Results in Table 3 show that female-headed households were leading in inter-cropping adaptation strategy at 58. 8% while male-headed households led in all other adaptation strategies. The finding is similar to that of Assan *et al*. (2018) who found out that male-headed households had better adaptive capacity than the female-headed households among smallholder farming communities in Ghana. This is despite more women being aware of climate change and variability than men (Hope, 2016). Households headed by people aged between 36 and 50 years were leading in using all adaptation strategies in the study area. This may be attributed to their age bracket which is vibrant in information sharing and farm management practices. Similar finding was reported by Nelson (2011) in a study on ways of coping with and adapting to climate change among smallholder farmers in Ghana from gender perspective. Among the three locations, Kanziku was leading in growing drought tolerant crops and inter-cropping while Mutomo was leading in growing short duration crop varieties, engaging in off-farm employment and mixed farming. This could be due to nearness to the sub-County agricultural offices and therefore likely to benefit from extension services and advise on adaptation. Households headed by people with primary level of education were leading in all adaptation strategies.

Results on linear regression of LVI of households on sixteen major adaptation strategies to rainfall variability yielded a p-value of 0.2076 and R^2 value of 0.0652 (Table 5).

Table 5: Regression of adaptation strategies on LVI

Source	Sum of Squares	DF	F	P-value	R^2
Model	0.92539	16	1.28	0.2076	0.0652
Residual	1.32698	294			
Total	**1.41952**	**310**			

Source: Author, 2019

Results in Table 4 indicates that 6.5% of the variation in LVI among the households in the study area is attributed to the model and it is not significant. This implies that adaptation to rainfall variability in Kitui South sub-County is generally inadequate and therefore does not significantly contribute to reduction of households' vulnerability. This is an indication that the adaptation strategies practiced in Kitui South sub-County do not reduce livelihood vulnerability of the households. The study finding contradicts that of Ogallo (2022) who found out that adaptation to rainfall variability among crop farming households of Soroti District of Eastern Uganda greatly contributed to improvement of LVI. This could be due to the fact that households of Kitui South sub-County used limited adaptation strategies as compared to those of Soroti District. On the other hand, the study finding is similar to that of Lyimo and Kangalawe (2010) who established that adaptation strategies did not improve LVI levels among rain-fed crop farming households in Shinyanga rural District of Tanzania.

Different adaptation strategies usually have different contribution to livelihoods of households depending of their usage. Multiple linear regression was, therefore, used to determine significance of each of the adaptation strategies to rainfall variability used in the study area to LVI. The main sixteen (16) adaptation strategies used by households in the study area for three years prior the study was regressed against LVI scores. Results are shown in Table 6.

Table 6: Significance of Adaptation Strategies to LVI

Variable	Coefficient	Standard Error	T	P-value	(95 % CI)	
Staggered planting	0.00899	0.00306	0.29	0.769	-0.00512	0.00692
Intercropping	-0.00122	0.00463	-0.26	0.792	-0.01033	0.00789
Irrigation	0.01172	0.01124	0.10	0.917	-0.02096	0.02330
Growing short-duration crops	0.00471	0.00366	1.29	0.199	-0.00249	0.01192
Agro-forestry	0.003069	0.00692	0.44	0.658	-0.01055	0.01669
Taking crop insurance	0.01572	0.01048	1.50	0.135	-0.00491	0.03635

Fallow cultivation	0.007721	0.01073	-0.72	0.472	-0.02884	0.01339
Rain water harvesting	-0.00445	0.00308	-1.45	0.149	-0.01051	0.00161
Off-farm employment	-0.00538	0.00363	1.48	0.140	-0.00177	0.01254
Remittance from family	0.003714	0.00338	1.10	0.273	-0.00295	0.01037
Mulching	-0.00175	0.00404	-0.43	0.666	-0.00970	0.00621
Crop rotation	-0.00197	0.00427	-0.46	0.644	-0.01037	0.00643
Mixed farming	-0.00440	0.00433	-1.02	0.310	-0.01292	0.00412
Reducing crop farming land	-0.00064	0.00318	-0.20	0.842	-0.00689	0.00562
Participating in work-for-food	0.00286	0.00364	0.78	0.433	-0.00431	0.01003
Developing water sources	-0.00613	0.00354	-1.73	0.084	-0.01309	0.00083
Constant	0.04362	0.01766	2.47	0.014	0.00885	0.07837

Source: *Author 2019*

According to Table 5, although all adaptation strategies to rainfall variability contributed to household's livelihood vulnerability, their contribution in reducing LVI levels among households was not significant. Strategies such as developing water sources, rain water harvesting, seeking off-farm employment and taking crop insurance showed some contribution to the lowering of LVI of households in the study area.

However, out of all the strategies, the one with the highest contribution to LVI was development water sources for irrigation with a p-value of 0.08. This finding could be attributed to the fact that Kitui South is a semi-arid area and, therefore, water is important for both major irrigation as well as supplementary irrigation. The low contribution of adaptation towards reduction of livelihood vulnerability to rainfall variability could be due to other factors associated with high LVI.

Conclusion

Results from primary and secondary sources of data as well as well as informant interviews confirmed that households in the study area were vulnerable to rainfall variability. Many stakeholders such as NGOs, CBOs and county government are involved in activities and projects aimed at reducing vulnerability and promoting adaptation to rainfall variability. Households in the study area, therefore, use many adaptation strategies to rainfall variability with developing water sources being the leading strategy. However, despite use of many adaptation strategies to rainfall variability, this does not have significant contribution to reduction of households' livelihood vulnerability to rainfall variability. Since adaptation strategies to rainfall variability do not significantly contribution to reduction of livelihood vulnerability, efforts should be made to reduce sensitivity of households to impacts of rainfall variability by improving food security of the household. This can be done through adopting measures aimed at addressing socio-economic factors which contribute to high levels of LVI among households as intervention measures to effects of rainfall variability in dry lands.

Recommendation

Although households have adopted several coping and adaptation mechanisms, these strategies have not significantly reduced livelihood vulnerability. Therefore, future interventions should shift focus from merely increasing the number of adaptation strategies to addressing the underlying factors that heighten household sensitivity to rainfall variability.

Efforts should prioritize improving household food security as a key pathway to reducing vulnerability. This can be achieved through targeted interventions that address the socio-economic factors contributing to high Livelihood Vulnerability Index (LVI) levels among households. Such measures may include strengthening income diversification opportunities, promoting climate-resilient agricultural practices, improving access to markets and agricultural inputs, and enhancing social protection mechanisms.

References

ADA. (2017). *Mainstreaming Climate Change into Planning: Lessons from five Arid and Semi-arid Counties.* ADA Consortium. Retrieved from https://adaconsortium.org/work/adaptation-and-resilience

Alexandratos, N., & Bruinsma, J. (2012). *World agriculture towards 2030/2050: The 2012 revision* (ESA Working Papers 12-03). Food and Agriculture Organization (FAO) of the United Nations. https://doi.org/10.22004/ag.econ.288998

Assan, E., Suvedi, M., Schmitt Olabisi, L., & Allen, A. (2018). Coping with and Adapting to Climate Change: A Gender Perspective from Smallholder Farming in Ghana. *Environments*, *5*(8), 86. https://doi.org/10.3390/environments5080086

Bruinsma, J. (2009). *How to feed the world in 2050* [Paper presentation]. Food and Agriculture Organization (FAO) of the United Nations. Retrieved from https://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

Cooper, P. J. M., Dimes, J., Rao, K. P. C., Shapiro, B., Shiferaw, B., & Twomlow, S. (2008). Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? *Agriculture, Ecosystems & Environment, International Agricultural Research and Climate Change: A Focus on Tropical Systems*, *126*(1), 24–35. https://doi.org/10.1016/j.agee.2008.01.007

Deressa, T., Hassan, R. M., & Ringler, C. (2008). *Measuring Ethiopian Farmers' Vulnerability to Climate Change Across Regional States*. International Food Policy Research Institute (IFPRI).

Dhaka, B. L., Chayal, K., Poonia, M. K., & Kendra, K. V. (2010). Analysis of farmers' perception and adaptation strategies to climate change. *Libyan Agriculture Research Center Journal International*, *1*(6), 388–390.

Dinesh, D., Campbell, B. M., Bonilla Findji, O., & Richards, M. B. (Eds.). (2017). *10 best bet innovations for adaptation in agriculture: A supplement to the UNFCCC NAP Technical*

Guidelines [Working Paper No. 215]. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Retrieved from https://hdl.handle.net/10568/89192

FAO. (2010). *"Climate-Smart" Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation*. Food and Agriculture Organization (FAO) of the United Nations. Retrieved from https://www.fao.org/4/i1881e/i1881e00.pdf

FAO. (2013). *Climate-Smart Agriculture: Sourcebook*. Food and Agriculture Organization (FAO) of the United Nations. Retrieved from https://www.fao.org/4/i3325e/i3325e.pdf

Füssel, H.-M., & Klein, R. J. T. (2006). Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking. *Climatic Change*, *75*(3), 301–329. https://doi.org/10.1007/s10584-006-0329-3

Gbetibouo, G. A. (2009). *Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa*. International Food Policy Research Institute (IFPRI).

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. *Global Environmental Change*, *19*(1), 74–88. https://doi.org/10.1016/j.gloenvcha.2008.11.002

Hansen, J. W., Baethgen, W. E., Osgood, D. E., Ceccato, P. N., & Ngugi, R. K. (2007). Innovations in Climate Risk Management: Protecting and Building Rural Livelihoods in a Variable and Changing Climate. *ICRISAT 35th Anniversary Symposium*, *4*(1). https://doi.org/10.7916/D8ZW1S4C

Hope, S. A. A. (2016). *Knowledge, Attitudes & Practices Study on Climate Change Adaptation & Mitigation in Guyana* [Climate Change KAP/B Study]. United Nations Development Programme (UNDP). Retrieved from https://www.adaptation-undp.org/sites/default/files/resources/climate_change_kap_survey_report_guyana_0.pdf

IPCC. (2007a). Climate change 2007: Impacts, Adaptation and Vulnerability. In M. Parry, O. Canziani, J. Palutikof, P. van der Linden, & C. Hanson (Eds.), *Contribution of Working Group II to the Fourth Assessment Report of the IPCC*. Cambridge University Press. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf

IPCC. (2007b). Climate change 2007: Mitigation of Climate Change. In B. Metz, O. R. Davidson, P. R. Bosch, R. Dave, & L. A. Meyer (Eds.), *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)*. Cambridge University Press. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg3_full_report-1.pdf

IPCC. (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, & L. L. White (Eds.), *Contribution of Working Group II to the*

Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (p. 1132). Cambridge University Press. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-FrontMatterA_FINAL.pdf

Jaetzold, R., Schmidt, H., Hornetz, B., & Shisanya, C. (2007). *Farm Management Handbook of Kenya: Natural Conditions and Farm Management Information: Vol. II* (2nd ed.). Ministry of Agriculture, Kenya. Retrieved from https://nishat2013.wordpress.com/wp-content/uploads/2013/11/farm-management-handbook.pdf

KNBS. (2010). *The 2009 Kenya Population and Housing Census* [National 2009 Census Report]. Kenya National Bureau of Statistics. Retrieved from https://www.knbs.or.ke/wp-content/uploads/2023/09/2009-Kenya-population-and-Housing-Census-Volume-1C-Population-Distribution-by-Age-Sex-and-Administrative-Units.pdf

Lyimo, J. G., & Kangalawe, R. Y. M. (2010). Vulnerability and adaptive strategies to the impact of climate change and variability. The case of rural households in semi-arid Tanzania. *Environmental Economics*, *1*(2), 89–97.

Macharia, P. N., Thuranira, E. G., Ngángá, L. W., Lugadiru, J., & Wakori, S. (2012). Perceptions and adaptation to climate change and variability by immigrant farmers in semi-arid regions of Kenya. *African Crop Science Journal*, *20*(2), 287–296. Retrieved from https://www.ajol.info/index.php/acsj/article/view/81720

Murphy, D., & Orindi, V. (2017). *sNAPshot Kenya's County Climate Change Funds: Country Brief 2B*. NAP Global Network. Retrieved from https://napglobalnetwork.org/wp-content/uploads/2018/01/napgn-en-2017-snapshot-kenya-county-climate-change-funds.pdf

Mwatu, M. M., Recha, C. W., & Ondimu, K. N. (2020). Assessment of Livelihood Vulnerability to Rainfall Variability among Crop Farming Households in Kitui South Sub-County, Kenya. *Open Access Library Journal*, *7*(6), 1–14. https://doi.org/10.4236/oalib.1106317

Nelson, V. (2011). *Gender, Generations, Social Protection & Climate Change: A thematic review*. Overseas Development Institute (ODI). Retrieved from https://odi.org/en/publications/gender-generations-social-protection-climate-change-a-thematic-review/

Ngaira, J. K. W., & Musiambo, M. (2012). Climate Change and Agricultural Development in Africa: Solutions and Challenges to Persistent Famine. *International Journal of Asian Social Science*, *2*(2), 153–168. Retrieved from https://archive.aessweb.com/index.php/5007/article/view/2171/3426

Ogallo, E. A., Wambua, B. N., & Mukhovi, M. S. (2022). Household vulnerability and adaptive capacity on impacts of climate change and adaptability solution in Soroti District, Uganda. *International Journal of Tropical Drylands*, *6*(2), 63–76. https://doi.org/10.13057/tropdrylands/t060203

RoK. (2013). Kitui County Integrated Development Plan 2013-2017. *County Government of Kitui*. Retrieved from http://10.0.0.19/handle/123456789/585

Sithole, A., & Murewi, C. T. F. (2009). Climate variability and change over southern Africa: Impacts and challenges. *African Journal of Ecology*, *47*(s1), 17–20. https://doi.org/10.1111/j.1365-2028.2008.01045.x

Steduto, P., Faurès, J.-M., Hoogeveen, J., Winpenny, J. T., & Burke, J. J. (Eds.). (2012). *Coping with water scarcity: An action framework for agriculture and food security*. Food and Agriculture Organization (FAO) of the United Nations. Retrieved from https://www.fao.org/4/i3015e/i3015e.pdf

Sultan, B., Baron, C., Dingkuhn, M., Sarr, B., & Janicot, S. (2005). Agricultural impacts of large-scale variability of the West African monsoon. *Agricultural and Forest Meteorology*, *128*(1), 93–110. https://doi.org/10.1016/j.agrformet.2004.08.005

UNFCCC. (2017). *UN Climate Change Annual Report 2017.* [Annual Report]. United Nations Framework Convention on Climate Change. Retrieved from https://unfccc.int/resource/annualreport/?source=post_page&utm

Yesuf, M., Falco, S. D., Deressa, T., Ringler, C., & Kohlin, G. (2008). *The impact of climate change and Adaptation on Food Production in Low-Income Countries: Evidence from the Nile Basin, Ethiopia*. International Food Policy Research Institute (IFPRI).