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Original Article

Socio-Economic Vulnerability and Adaptations of Fish Farmers to Climate Variability and Extreme Climate Events in Selected Parts of Kitui County, Kenya

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ABSTRACT

Climate variability and extreme climate events is one of the many challenges faced by fish farmers. The present study was carried out to assess and compare the socio-economic vulnerability and adaptations of fish farmers to climate variability and extreme climate events in arid and semi-arid lands of Central and Eastern parts of Kitui County, Kenya. Both study sites were purposively selected and the descriptive research design adopted. A total of 60 fish farming households were randomly selected to form the sample size for the study. The socio-economic vulnerability analysis of the fish farmers was based on an index constructed from carefully selected indicators for adaptive capacity. Principal Component Analysis was used to give weights to the indicators. The overall adaptive capacity index results revealed that possession of various assets varied between the two study sites, implying a spatial difference in socio-economic vulnerability between the two study sites. Regarding adaptation, results revealed that the level of adoption of various adaptation strategies to climate variability and extreme climate events also differed significantly between the two study sites and was subject to the adaptive capacity of the fish farmer. Therefore, this study recommends that the socio-economic vulnerability profile of the fish farmers inform any adaptation actions to be taken on fish farmers in arid and semi-arid lands.

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INTRODUCTION

Climate variability and extreme climate events are reported to cause significant implications on global trade and the availability of fish and fish products (Intergovernmental Panel on Climate Change [IPCC], 2007), hence affecting the livelihoods of fish farmers either directly or indirectly. The concept of vulnerability is often considered to have its roots in the study of natural hazards (Hewitt, 1983). Adaptation to climate variability and extremes by fish farmers has therefore been highlighted as crucial (Adger, 2006). Fish farmers in Arid and Semi-Arid Lands (ASALs) are at a greater risk as fish farming in these areas is majorly rain-fed and these areas are characterized by erratic rainfall, high evaporations, and frequent and severe droughts. Concurrently, fish farmers in developing nations are more vulnerable due to their poor adaptive capacity (Badjeck *et al*., 2010; Adger, 2006), attributable to low economic positions, inadequate institutional support, and insufficient technological development in fisheries (Adimassu and Kessler, 2016). This is despite the fact that the number of fishers and fish farmers has been growing faster than employment in traditional agriculture in the past three decades, mainly in developing countries (Food and Agricultural Organization [FAO], 2012).

Production and consumption of fish products is also concentrated in the developing world, contributing significantly to both total gross domestic product (GDP) and agricultural GDP as well as food security (FAO, 2007). Spatial variation in vulnerability levels to climate variability and extremes on fish farmers within similar regions is reportedly present subject to the adaptive capacity of fish farmers (Morton, 2007). While Qing and Maria (2018) identifies vulnerability as either biophysical or social-economic, Brooks (2003) finds biophysical vulnerability to be the effects of hazards such as droughts, floods, rainfall variation, and the damage they cause on a system. Social-economic vulnerability is concluded to solely focus on social properties of a system like poverty, incomes, unemployment, and migration (Brooks, 2003) which make the system more vulnerable to environmental hazards compared to other systems. This study focused on social-economic vulnerability of fish farmers to climate variability and extreme climate events.

Globally, fishing communities have developed local adaptation strategies to climate variability implications based on their day-to-day experiences (Salick & Byg, 2001; Macchi *et al.*, 2008; Danielsen, 2005). Ndamani and Watanabe (2015) also noted that adaptation strategies are pre-emptive in nature and therefore help mitigate foreseen effects of climate change and that any adaptation

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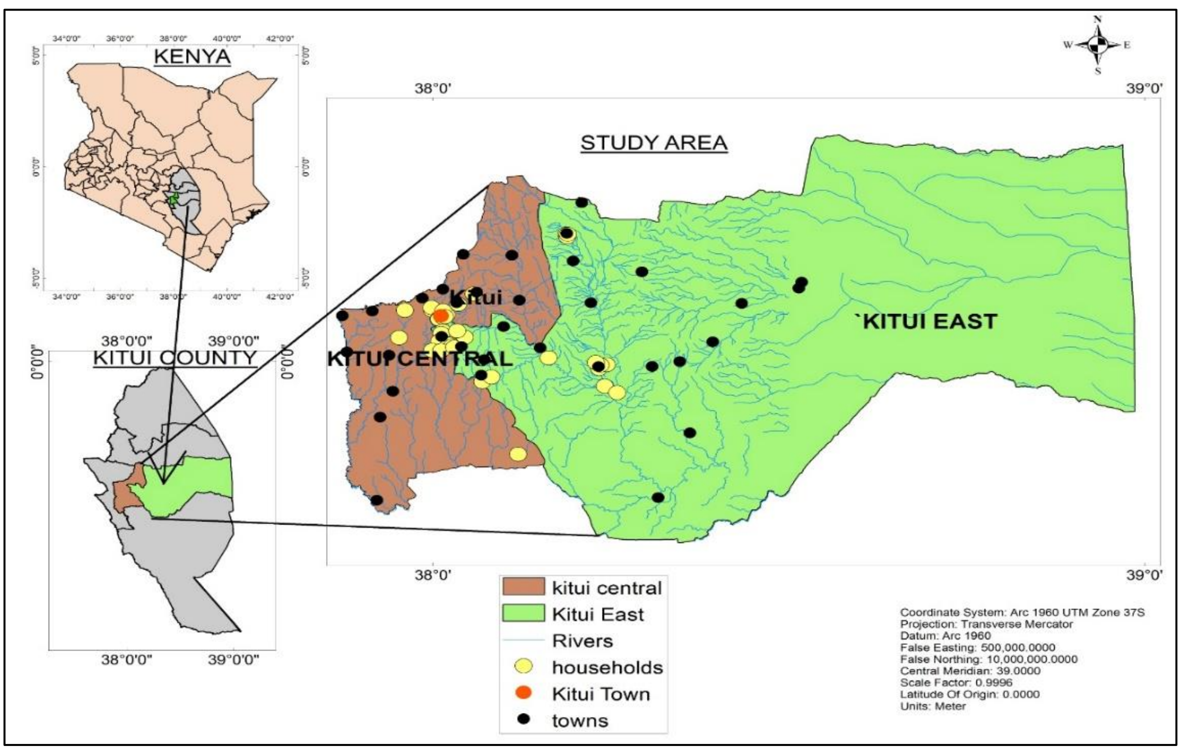
actions should be informed by empirical data. The choice of an adaptation strategy is location/household specific (Luni *et al.*, 2012) and depends on the socio-economic characteristic of a household/farmer (Mutunga *et al*., 2018). Therefore, understanding local and household adaptation strategies amongst fish farmers is crucial. Mwangi et al. (2020) vouches for carrying out of local-household vulnerability assessments prior targeting adaptation assistance. Within this context, the present study assessed the socio-economic vulnerability of fish farmers in selected parts of Kitui County and adaptation strategies they have put in place to counter effects of climate variability and extreme climate events. It is expected that the results of the study will guide management initiatives and decisions by all fish farming stakeholders in arid and semi-arid lands (ASALs) and help them introduce applicable and most preferred adaptation strategies by fish farmers. It will also provide an overview of the level of socio-economic vulnerability of fish farmers in the study area and in ASALs of Kenya in general and hence inform decision making.

MATERIALS AND METHODS

Profile of the Study Area

The study was conducted in Kitui Central and Kitui East Sub Counties in Kitui County in South Eastern part of Kenya (*Figure 1*)

Figure 1: A map showing the study area



Source, ILRIS GIS Database

Most parts of the County have arid and semi-arid climates with rainfall distribution that is unreliable and erratic (Kitui County Integrated Development Plan [KCIDP], 2018). The Countys' lowest annual average temperature is 14^0C, while the highest annual average temperature is 32 ^{0}C (Republic of Kenya [ROK], 2010), which is occasionally lower than the 20 ^{0}C requirement for fish to thrive. Agriculture in the County is primarily rain-fed, with the inhabitants practicing; crop farming, livestock

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keeping, beekeeping, poultry farming, and fish farming. Further, the study area exhibits bimodal rainfall patterns that varies from 500 mm to 1050 mm and has a 40% reliability. Fish farming in the County is predominantly done under rain-fed conditions which affects fish farmers.

Study Design and Sampling Technique

A descriptive research design was used and the study focused on individual fish farmers' households as the unit of analysis. Purposive sampling technique was used to select two study sites, Kitui Central Sub-County and Kitui East Sub-County. The households interviewed were selected by the use of simple random sampling from a list of fish farmers obtained from records in the government fisheries department in Kitui County.

Data Collection and Analysis

Primary data for the study was collected through a household survey interview schedule and participant observation. Trained research assistants visited selected household sites and conducted face-to-face interviews with the household heads. Secondary data was collected through the analysis of literature. Statistical Package for Social Sciences (SPSS) version 22 and Ms Excel were used to analyse the data.

Adaptive Capacity of the Fish Farmers in the Study Area

The adaptive capacity of the fish farmers represented the socio-economic Vulnerability of the fish farmers in the study area. Adaptive capacity was operationalized as a function of five household assets (human, financial, physical, natural, and social) following the sustainable livelihoods approach (Department for International Development [DFID], 2000), as indicated in Table 1. All the assets possess the ability to reduce the risks brought by climate shocks by minimizing, pooling, and redistributing climate risks.

Construction of Socio-Economic Vulnerability Index

Selection of indicators for the five livelihood assets was carried out from the review of the literature and discussions with the key stakeholders. Consequently, their relationship with adaptive capacity was indicated as illustrated in Table 1 and normalization done following the United Nations Development Programme (UNDP) Human Development Index (HDI) (UNDP, 2006). Normalization was done for standardization of the various indicators with different units such that all normalized values lie between 0 and 1. The following formulae was used.

$$Normalized\ value = \frac{Observed\ value - Mean}{Standard\ deviation}$$

After normalization, weights were assigned to the indicators using the Principal Component Analysis (PCA) following Filmer and Pritchett (2001). PCA was run on the indicators for each livelihood asset separately in SPSS. Loadings from PCA that were highly correlated to the indicators were used as the weights of the indicators. Multiplication of the normalized values with their respective weights was done to generate the sub-composite index for each livelihood asset. The steps are summarized by the following formulae;

$$I_j = \sum_{i=1}^{k} b_i [\frac{a_{ji-x_i}}{si}]$$

Whereby; I is the respective index value for the jth household; b is the weighted value for the ith indicator; a is the ith indicator value for jth household; x is the mean value for the ith indicator; and S is the standard deviation for the ith indicator value.

The final socio-economic vulnerability index for the fish farmers was calculated by using the formulae;

$$V = AC$$

Whereby; V represented the socio-economic vulnerability index and AC represented the adaptive capacity index of the fish farmers in the study area.

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Additionally, the Livelihood Diversification Index (LDI) was used as one of the indicators for financial assets as shown in Table 1. The income structure can be from various sources, and usually, a higher number of sources of income reduces the effects of climate variability and extreme climate events, and vice-versa. Therefore, to capture the income structure aspect of the fish farmers, the LDI was calculated using the Herfindahl-Hirschman index of diversification as applied by (Piya *et al.*, 2012).

$$D_k = 1 - \sum_{i=k}^{N} S_{ik}{}^2$$

whereby; D_k is the livelihood diversification index, i is the specific livelihood activity, N is the total number of activities being considered, k is the particular household, and S_{ik} is the share of i^{th} activity to the total household income for k^{th} household.

Table 1: A Summary of the Indicators for Adaptive Capacity in the Study Area

Indicator	Description of the indicator	Unit	Relationship with socio-economic vulnerability
Physical assets	Number of early sources of weather information	Number	+
	Distance to a motorable road	(Km)	-
	Number of fish farming equipment	Number	+
	Number of culture units present in a household	Number	+
	Distance to the nearest permanent water source	(Km)	-
	Total volume in litres of all water storage facilities on the farm	(L)	+
Human assets	Number of fish farming training attended by family members	Number	+
	Number of schooling years of the household head	Number	+
	The number of persons in the household having salaried employment?	Number	+
Natural assets	Number of drought animals in a household	Number	+
	The average number of fish stocked within a cycle	Number	+
	Number of fish species stocked in a household	Number	+
	Total land size devoted to fish farming in a household	In acres	+
	The total size devoted to fish farming in a household	In acres	+
Social assets	The number of CBOs a household head is registered in	Number	+
	Number of credit facilities accessed in the last ten years	Number	+
	Number of times household members have accessed extension services in the last three years	Number	+
Financial Assets	Average gross monthly income within the household from all income-generating activities (KES)	In KES	+
	Average monthly household savings	In KES	+
	Livelihood diversification index		+

Source: Modified from Piya *et al.* (2012), IPCC (2007), and Luni *et al*. (2012)

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Adaptation Strategies Adopted by the Fish Farmers in the Study Area

The adaptation strategies adopted by the fish farmers to reduce their vulnerability to climate variability and extreme climate events in the study area were identified using a household survey interview schedule. The adaptation strategies were divided into three major categories; adaptation in response to changing precipitations, adaptation in response to changing temperatures, and adaptation to extreme events.

RESULTS AND DISCUSSION

Adaptive Capacity of the Fish Farmers

Examination of the results on mean values of various indicators of adaptive capacity as presented in *Table 2* revealed that fish farmers in Kitui Central Sub County recorded higher scores in most of the asset categories compared to fish farmers in Kitui East. Regarding the physical assets, Kitui Central fish farmers had a higher number of physical assets compared to Kitui East fish farmers. In addition, the sub-composite indicators' mean values for physical assets were significantly different ($p<.05$) except for the distance to the nearest motorable road and the distance to the nearest permanent water source. Therefore, physical livelihood assets varied between both Sub Counties which was attributed to Kitui Central fish farmers being near County headquarters and could find off-farm income enabling them to purchase physical assets compared to Kitui East fish farmers in a rural setup. Deressa *et al.* (2008) support this finding by pointing out that households in remote areas have low developments than their counterparts near towns which increases their susceptibility to environmental damage.

Regarding natural assets, the mean values for natural assets sub composite index indicated that Kitui East fish farmers had a higher possession of natural assets (total land size (13.87), number of draught animals (2.93), and land size devoted to fish farming (2.13). The difference in the mean values of the land size is again attributed to the fact that Kitui East households had more extensive land due to less population in the Sub County compared to Kitui Central, which is within and around the County headquarters and densely populated. Seto *et al.* (2000) corroborates this finding by noting that most agricultural land around urban centres has been developed in most developing countries, resulting in the loss of arable lands around urban centres.

The study also established that Kitui Central fish farmers had attended a higher number of fish farming training sessions (0.84) compared to their counterparts in Kitui East (0.30), which is explained by their proximity to the County headquarters and institutions dealing with fish farming in the area. Fish farming trainings are found to be key in upgrading the fish farmers' knowledge of fish farming, enabling them to solve any challenges in their fish farming business (Kimathi, 2013). The mean values also revealed that Kitui Central had a higher number of people with salaried employment (0.64) and household heads with higher schooling years (11.53) compared to Kitui East. The education level manifests in building an understanding concept and working principles of appropriate technologies in fish farming. Additionally, higher education levels prove to translate into getting more off-farm income hence increasing the adaptive capacity of a household. The findings are corroborated by Nzevu *et al.* (2018), who found a positive but insignificant relationship between the education level/number of schooling years and the adoption of modern technologies in fish farming in Kitui Central Sub County.

Among the social assets, the mean values of the indicators revealed that household heads in Kitui Central had a higher number of memberships to community-based organizations (1.53), access to credit facilities in a period of ten years (1.70) and number of times household members had accessed extension services in a period of three years (1.37) compared to fish farmers in Kitui East. Noteworthy,

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the independent-samples T-test performed to compare social assets in both study sites revealed that all the indicators were statistically significant (p<.01) implying that social assets varied between the two study sites.

The results also revealed that all the indicators of financial livelihood assets had a positive weighting, hence contributing positively to the financial assets' sub-composite index. The trend in the results is in conformity with the findings in Fagariba *et al.,* (2018) and, Chepkoech *et al.,* (2020), who conclude that household income, savings, and diversification in income streams increase the adaptive capacity of households. The examination of the results further revealed that the mean values of all financial assets indicators were higher in Kitui Central compared to Kitui East. Financial asset has been highlighted as important as they can be transformed into other asset types (Luni *et al.*, 2012). Therefore, one of the primary focuses in Kitui East should be improving their financial assets base, which would enhance other asset categories like social, physical, human, and natural assets hence maintaining their households' economies.

Further, the study results revealed that Kitui East fish farmers had diversified their income streams compared to fish farmers in Kitui Central, as depicted by the livelihood diversification index. The possible explanation for the finding is the presence of a vast array of natural resources-based activities ranging from aquaculture, crop farming, livestock keeping, beekeeping, and sand harvesting to selling forestry products. The finding is in line with Fagariba *et al.* (2018), who found a positive correlation between livelihood diversification and the adaptive capacity of households.

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Table 2: Mean values for the indicators of adaptive capacity in the study area

	Indicators	Weight	Sub County		P-Value
			Kitui Central	Kitui East	
Physical assets	Number of early warning sources of weather information	0.72	3.20(1.45)	1.47(0.86)	.00***
	Sum of all culture units in a household	0.76	2.57(1.22)	1.07(0.25)	.00***
	Sum of all fish farming equipment	0.88	8.83(3.34)	3.27(1.31)	.00***
	Distance to the nearest motorable road	0.61	0.80(0.76)	0.63(0.85)	0.43
	Distance to the nearest permanent water source	0.78	0.92 (1.05)	1.07(1.05)	0.58
	Total water storage in a household	0.46	17,202.33 (28,701.42)	4,700.00 (3453.14)	.02**
Natural assets	Total land size owned by household(acres)	0.93	6.95(11.29)	13.87(25.82)	0.19
	Total land size devoted to fish farming in the household	0.92	1.27(2.03)	2.13(3.66)	0.27
	Number of drought animals owned by a household	0.58	0.73(1.72)	2.93(2.92)	.00***
	Number of fish species cultured in a household	0.63	1.27(0.25)	1.10(0.31)	0.14
	The average number of fish stocked within a cycle	0.8	357.67 (303.04)	255.67 (176.45)	0.12
Human assets	Number of schooling years of the household head	0.77	11.53(4.34)	10.63(4.46)	0.43
	Number of persons with salaried employment in the household	0.64	0.83(0.75)	0.53(0.73)	0.12
	Number of fish farming training attended by household members	0.84	1.67(1.18)	0.30(0.54)	.00***
Social assets	Number Community-based Organizations household head is a member	0.85	1.53(0.57)	0.50(0.63)	.00***
	Number of credit facilities accessed in the last ten (10) years	0.6	1.70(1.51)	0.40 (0.72)	.00***
	Number of times household members have accessed extension services	0.79	1.37(1.10)	0.27(0.52)	.00***
Financial assets	Average gross monthly income within the household from all income-generating activities (Ksh)	0.83	23300.00 (20472.27)	8216.67 (7488.71)	.00***
	Average monthly savings (Ksh)	0.85	5183.33 (3379.668)	2083.33 (1939.09)	.00***
	Livelihood diversification index	0.23	0.38(0.25)	0.47(0.24)	0.15

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Adaptive Capacity Indices

The weights and mean values of various indicators of adaptive capacity after the second step PCA are presented in *Table 3*. All the weights of the indicators of overall adaptive capacity were positive, implying a positive contribution to the adaptive capacity index. The social assets index (0.85) had the highest contribution towards the adaptive capacity index in the study area, followed by physical assets index (0.79), natural assets index (0.79), financial assets index (0.73), and lastly, human assets index (0.65). Social networks like membership in community-based organizations, merry-go-rounds and local institutions are crucial in enhancing the adaptive capacity to climate variability and extreme climate events. Therefore, more efforts should be directed to improving the fish farmers' social assets base in the study area. The observation is alluded by Munguti *et al.* (2014) who indicated a positive correlation between productivity and adoption of fish farming in Kenya with access to credit. Financial assets should also be of primary focus in the study sites whereby, development projects should maximize in creation of off-farm incomes. Independent-samples T-test performed to compare adaptive capacity in both study sites revealed that physical, social, and financial assets were statistically significant ($p<.01$). However, the mean values for the natural and human assets index were not statistically significant at a 95% confidence level.

Table 3: Weights and Mean Values for Overall Adaptive Capacity Indicators in the Study Area

Indicator	Weight	Sub-County		*P*-Value
		Kitui Central n=30	Kitui East n=30	
Physical assets index	0.79	1.70(1.97)	-1.71(1.07)	.00***
Natural assets index	0.79	-0.20(1.74)	0.21(2.95)	.52
Human assets index	0.65	0.01(1.18)	-0.01(1.18)	.95
Social assets index	0.85	1.26(1.29)	-1.28(0.94)	.00***
Financial assets index	0.73	1.29(1.73)2	-0.24(0.70)	.00***

Note: Figures in parenthesis indicate standard deviation
**** indicate significant at 1% level of significance*

Adaptation of Fish Farmers

The study results indicated that fish farmers in the study area had adopted various strategies as a precautionary response to climate variability and extreme climate events. The observation concurs with findings by Coulthard (2009), who noted that fish farming households and their communities were actively adapting against changes affecting the fish farming sectors.

Adaptation in Response to Changing Precipitation

Fish farmers in the study area had adopted multiple strategies in response to changing precipitation as indicated in *Table 4*. Fish farmers in Kitui Central had a higher adoption of farming hardy fish like catfish, which were tolerant to reducing precipitations (60%) compared to Kitui East Sub County (40%). The results are in line with Lebel *et al.* (2015), who indicated that fish farmers in Thailand had switched from Tilapia to more tolerant catfish fish species in response to climate-related risks like reduced dissolved oxygen. Fish farmers in Kitui Central (86.7%) and 33.3% of fish farmers in Kitui East reported having shifted from fish farming to other agricultural activities. Further, 76.7% of fish farmers in Kitui Central and 6.7% of fish farmers in Kitui East had shifted from other agricultural activities to fish farming. The current

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trend of results was observed as a result of recurrent losses from the fish farming business hence the need for an alternative source of incomes. Similar findings were reported by Boonstra and Hahn (2015) who noted that fish farmers in Vietnam had resorted to rice cultivation as an adaptation strategy when there were floods due to huge precipitations and later reverted to fish farming when precipitation decreased.

Integration of fish farming with other agricultural activities was another common practice and was also highly adopted amongst fish farmers in Kitui Central 90% compared to Kitui East 73.3%. The practice was commonly done to cushion fish farmers from either failure. The results are in line with findings by Kumar *et al.* (2017), which indicated that farmers in Coastal India adopted traditional integrated farming systems; whereby fish was grown on the same piece of land as crops and livestock, and outputs from either could be used as inputs for the others.

Water is crucial in fish farming enterprises, and fish farmers in the study area had adopted various strategies to ensure adequate water for the fish farming activities. Results revealed that agroforestry and a general increase in the number of vegetation cover were standard practices by the fish farming households in the study area. The adoption of this strategy has been reported in other studies. Fagariba *et al.* (2018) reported the adoption of agroforestry in the Sissala West district while Dubey *et al.* (2017) noted that fish farmers planted trees around pond dykes to reinforce the dykes in India. In addition, the study results showed that all adaptation strategies against changing precipitation were statistically different across the study sites except for farming hardy fish tolerant to climate change, integrating fish farming into other agricultural activities, and increasing vegetation cover to attract rain. The results are in concurrent with findings of (Mutunga *et al.*, 2017; Ndamani and Watanabe, 2015), who noted a correlation between the adoption of adaptation strategies by different households and communities in their study areas with levels of education, income, awareness, sensitivity, and vulnerability. Further, Egyir *et al*. (2015) pointed out off-farm income as crucial in adopting many adaptation strategies, hence improving the adaptive capacity of households.

Table 4: Adaptation strategies (%) used by fish farmers in response to changing precipitations in the study area

Adaptation strategy	**Sub County**		**p-value**
	Kitui Central	**Kitui East**	
Farming hardy fish tolerant to climate variability and extreme events	60%	40%	0.60
Shifting from fish farming to other agricultural activities	86.7%	33.3%	0.00***
Shifting from other agricultural activities to fish farming	76.7%	6.7%	0.00***
Integration of fish farming into other agricultural activities	90%	73.3%	0.10
Practicing fish farming when water is available	66.7%	20%	0.00***
Building water harvesting schemes	90%	70%	0.05**
Reusing water	83.3%	36.7%	0.00***
Changing stocking time	70%	23.3%	0.00***
Stocking different rearing units at different intervals	33.3%	10%	0.03**
Increased vegetation cover to attract rain	90%	76.7%	0.17
Incorporation of Water conservation techniques in fish farming	90%	46.7%	0.00***

*Note: ***, ** indicates significance at 1% and 5% level of significance*

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Adaptation in Response to Changing Temperatures

Fish farmers in the study area adopted several adaptation strategies to counter changing temperatures, as indicated in *Table 5*. About 80% of the fish farmers in Kitui Central and 56.7% of fish farmers in Kitui East had opted to repair slightly damaged culture units especially liner ones instead of purchasing new ones since drying of ponds exposed them to damage by heat. The results further revealed that 90% of fish farmers in Kitui Central and 36.7% in Kitui East preferred stocking juvenile fish (up to 30 g) instead of fry (up to 6 g). Juveniles reportedly had better survival percentages, outputs, and potential to survive the high temperature. Interestingly, 76.7% of fish farmers in Kitui Central and 46.7% in Kitui East had reduced stocking due to the poor return on investment in fish farming. The observation was reported to be a result of increased temperatures coupled with lesser rainfall which increased the cost of maintaining water levels in culture units, increased fish losses, and damage to the culture units. Similar findings were obtained in studies by Lebel *et al.,* (2015); Navy *et al.,* (2017) and Pelletier *et al.,* (2014) who noted that fish farming communities had reduced their overall stocking densities as an adaptation strategy.

Table 5: Adaptation strategies (%) used by fish farmers in response to changing temperatures in the study area

Adaptation strategy	**Sub-County**		***P*-value**
	Kitui Central (n=30)	**Kitui East (n=30)**	
Frequent repairs of slightly damaged culture units (earthen linen ponds)	80%	56.7%	0.05**
Stocking juveniles (up to 30 g) instead of fry (up to 6g)	90%	36.7%	0.00***
Reducing fish stocking	76.7%	46.7%	0.02**

*Note: ***, ** indicates significance at 1% and 5% level of significance*

Adaptation in Response to Extreme Climate Events

In response to extreme climate events (droughts, fish diseases, and high precipitation), 3.3% of fish farmers in Kitui Central and 6.7% of fish farmers in Kitui East had procured insurances for their fish farming businesses. Most fish farmers in the study area who had not procured insurance had opted to be self-insured owing to the high costs of fish farming insurance and small-scale nature of their fish farming business. The findings are in agreement with Olayinka *et al.* (2018), who, in their study in Ondo State, Nigeria, concluded that most fish farmers did not procure insurance due to the small-scale status of their fish farming business. Mohanty (2018) found adoption of aquaculture insurance as an adaptation strategy amongst shrimp farmers in India.

About 30% of fish farmers in Kitui Central and 10% of fish farmers in Kitui East had procured loans to keep their fish farming business afloat. Further, scrutiny of the study results revealed that fish farmers in the study area had sought county government support. However, Kitui Central fish farmers reported a higher county government support (56.7%) compared to fish farmers in Kitui East (50%) which can be attributed to their proximity to the County headquarters. The results are in consonance with findings by Azra *et al.* (2020), who noted seeking government support as one of the many adaptation strategies adopted by aquaculture communities to counter the effects of climate change.

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Finding off-farm jobs was also common in supplementing the income from the fish farming business. This adaptation strategy was mainly observed amongst fish farmers in Kitui Central at 66.7% compared to fish farmers in Kitui East Sub County (26.7%). The study results also revealed that all adaptation strategies to counter extreme climate events in the two study sites were statistically different except for procurement of insurance for fish farming business and seeking county government support. Overall, Kitui East fish farmers had less adoption of these strategies compared to Kitui Central fish farmers, which can be attributed to their lower adaptive capacity. The study results are in line with Nielsen and Reenberg (2010), who concluded that diversity in income streams and adaptive capacity are closely associated with better adaptation and response towards climate variability and change, hence reducing the sensitivity of households.

Table 6: Adaptation strategies (%) used by fish farmers in response to extreme climate events in the study area

Adaptation strategy	Sub-County		***P*-value**
	Kitui Central	**Kitui East**	
Procuring insurance for the fish farming business	3.3%	6.7%	0.55
Seeking County government support	56.7%	50%	0.61
Procuring loans	30%	10%	0.05**
Finding off-farm jobs	66.7%	26.7%	0.00***

*Note: ***, ** indicates significance at 1% and 5% level of significance*

CONCLUSION AND RECOMMENDATIONS

The study revealed that fish farmers in Kitui East and Kitui Central faced socio-economic vulnerability portrayed by the poor adaptive capacity in the two study sites. Further, the existing adaptive measures by the fish farmers in the two study sites were not sustainable due to the unpredictability of the changing climate and occurrence of extreme climate events. The study, therefore, recommends active support for adaptation in the fish farming industry from national, regional, and local levels of governance. The support should variously include; provision of extension and training services to the fish farmers in ASALs, uptake of climate smart fish farming, training, and support to acquire appropriate rainwater harvesting technologies as well as development of policies that enable ability and access to financial credits, among others. Further, the study recommends creation of more off-farm income opportunities to fish farmers, thereby reducing the high dependence on natural resources-based income, hence reducing the overall socio-economic vulnerability of the fish farmers to climate variability and extreme climate events. Policy makers should also consider fish farming as a solution to food security concerns in Kitui County and target women which can further improve their contribution into fish farming and enhance their livelihoods.

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