aquaculture journal

Article

Determinants of Households' Resilience to Covariate Shocks: Empirical Evidence and Policy Implications from the Kenyan Fisheries and Aquaculture Sectors

Silas Ochieng [1,*], Erick Ogello [1], Kevin Obiero [2] and Maureen Cheserek [3]

1 Department of Animal and Fisheries Sciences, Maseno University, Private Bag, Maseno P.O. Box 3275-40100, Kenya
2 Sangoro Aquaculture Research Center, Kenya Marine and Fisheries Research Institute (KMFRI), Pap-Onditi P.O. Box 136, Kenya
3 Department of Human Nutrition, Faculty of Health Science, Egerton University, Njoro P.O Box 536-20115, Kenya
* Correspondence: silasochieng85@gmail.com

Abstract: This paper analyzes the factors influencing households' resilience capacities to shocks within Kenya's fisheries and aquaculture sectors and draws from primary data collected from 419 fish-dependent households across Kisumu, Busia, Mombasa, and Kilifi counties. The sample represents a total of 48,000 fishing households. The study adopted a quasi-longitudinal design and computed the household resilience capacity index (RCI) using the resilience index measurement and analysis (RIMA-II) model. The results indicate that male-headed households' mean household RCI scores (mean = 45.07 ± 10.43) were statistically significant to that of female-headed households (mean = 38.15 ± 9.25), suggesting that female-headed households are associated with lower resilience capacities than male-headed households. Moreover, the study identifies differences in resilience levels across various occupations within the sector. For instance, RCI scores among fish traders (mean = 40.71 ± 9.97), a function performed mainly by women, statistically differed ($p < 0.005$) from male-dominated cage farming (mean = 48.60 ± 10.47), whereas RCI scores at the production level for fisher folks (mean = 44.89 ± 10.09) and pond farmers (mean = 44.04 ± 12.07) showed no statistical difference (0 > 0.05. Additionally, households with more income sources tend to have higher resilience capacities. Seasonality in fishing cycles limited households' ability to recover from climate-induced shocks; the more months without fishing activity, the less the odds of recovery from shocks (OR = 0.532, 95% CI [0.163, 0.908], $p = 0.022$). Furthermore, households that lacked guaranteed market access and inputs during COVID-19 were less likely to recover during and after the shocks (OR = 0.401, 95% CI [0.161, 0.999], $p = 0.05$). Households organized in cooperatives with better access to credit showed a higher chance of recovery. The study recommends (a) adopting gender-sensitive approaches in fisheries and aquaculture interventions to empower women in trade, (b) strengthening policies to enhance access and adoption of climate-smart technologies such as cage fish farming, (c) promoting livelihood diversification to sustain households' income during fishing off-seasons, and (d) enhancing market linkages in the fish value chain through coordinated producer organizations. Further research should explore the possibilities of introducing index-based weather insurance and other tested suitable safety nets for the fisheries and aquaculture sector.

Keywords: household; resilience; fisheries; aquaculture; Kenya; covariate shocks

check for updates

Citation: Ochieng, S.; Ogello, E.; Obiero, K.; Cheserek, M. Determinants of Households' Resilience to Covariate Shocks: Empirical Evidence and Policy Implications from the Kenyan Fisheries and Aquaculture Sectors. *Aquac. J.* **2024**, *4*, 203–216. https://doi.org/10.3390/aquacj4030015

Academic Editor: Aires Oliva-Teles

Received: 5 July 2024
Revised: 31 August 2024
Accepted: 4 September 2024
Published: 13 September 2024

1. Introduction

Kenya's fishing sector is crucial to its economy, contributing about 2 percent to export earnings and around 0.5 percent to the gross domestic product (GDP) [1]. It employs over 1.2 million people indirectly across various supply chain stages, from fishing and production to distribution [1]. The annual demand for fish in Kenya is estimated at

450,000 metric tons against a supply of 164,000 metric tons [2]. Freshwater ecosystems such as Lake Victoria, Lake Turkana, Lake Naivasha, and Lake Baringo, along with coastal and open sea environments, are significant sources of revenue and sustenance for this sector. Freshwater aquaculture, driven by favorable regulations and substantial public investment over the past two decades, has emerged as the fastest-growing sub-sector in Kenya, with annual production reaching 31,655 tons in 2023 and accounting for 19.6% of Kenya's total fish output [2]. As a result, fish has become essential to Kenya's food systems, improving nutritional outcomes and promoting dietary diversity [3,4].

Despite the socio-economic importance of Kenya's aquatic resources, the fisheries and aquaculture sectors experience significant vulnerabilities from various shocks. These include climate change, the COVID-19 pandemic, and geopolitical instability, all posing significant threats to the industry's sustainability [5–7]. The increasing frequency and diversity of shocks adversely affect biological systems, biodiversity, and ecosystem processes [8]. Climate disturbances such as droughts and floods particularly impact the two sub-sectors, posing severe challenges to their resilience [9]. The impacts of these shocks result from complex processes influenced by various spatially distributed biophysical, socio-economic, cultural, and institutional factors [10,11]. Fish species respond to environmental changes by altering their distribution, phenology, metabolic rates, growth, and reproduction [11], significantly affecting food security. For instance, fish migration to more favorable habitats can drastically affect fishers who cannot relocate due to political and economic constraints [12]. Furthermore, a decline in fish production affects export revenues, reduces households' food consumption, and increases national food insecurity. The COVID-19 pandemic introduced additional challenges to the fish supply chain, disrupting the input supply chain, delivery of technical assistance, product sales, and transportation, in addition to the imposition of export restrictions [13]. These challenges resulted in decreased earnings, unplanned stock retention, and reduced production, causing fish farmers to lose interest in aquaculture [14]. Geopolitical instability, exemplified by the Ukrainian conflict and national political unrest in Kenya, exacerbates these issues, affecting liquidity, labor, and the overall stability of the fisheries and aquaculture sectors [15].

Although previous studies have documented the impacts of covariate shocks on aquatic food systems [16,17], still, there is a lack of empirical evidence on how households engaged in Kenya's fisheries and aquaculture sectors manage and recover from such events. The existing literature primarily focuses on general agricultural resilience or isolated components, such as financial or social capital, rather than providing a comprehensive understanding of household resilience in these sectors [18]. Additionally, while some studies have addressed the impacts of covariate shocks, there is limited insight into the recovery processes and the factors that either bolster or hinder household resilience over time [19]. Resilience, defined as the capacity of households to withstand adverse stressors and shocks without long-term negative consequences, is crucial for sustainable development [20,21]. Evaluating resilience assists in identifying strategies to enhance households' capacity to endure shocks, crucial for sustaining the well-being of individuals directly and indirectly involved in fisheries and aquaculture [19–22]. However, much of this research emphasizes community or regional resilience, often neglecting the specific dynamics at the household level within the fisheries and aquaculture sectors . Although resilience capacities can enable households to withstand shocks and stresses, some shocks may still significantly affect these outcomes and resilience levels [18,23].

Therefore, understanding the factors determining household resilience amidst covariate shocks is essential for designing programs that safeguard livelihoods and enhance resilience. This information is crucial for designing policies that protect and prepare households for future shocks. Hence, this study analyzes the factors influencing household resilience to covariate shocks within Kenya's fisheries and aquaculture sectors.

2. Materials and Methods

2.1. Study Site

The study sites were purposively selected to represent two key capture-fisheries regions (freshwater ecosystem) and two main marine ecosystems. These included Kisumu and Busia (freshwater lake) and Mombasa and Kilifi (marine). These areas were chosen because of their predominance of fish-farming activities and the rich blue economy resources. The main source of livelihood in the regions is fishing and fish farming, and therefore, any changes affecting the value-chain actors occasioned by the emerging stressors (droughts, floods, COVID-19 pandemic, and geopolitical instability) are likely to have an influence on the fisher folks' and fish farmers' livelihood. For both capture and aquaculture fish value chains, Kisumu and Mombasa are the two largest consumption urban cities. Mombasa is a major producer of marine and freshwater fish species and a port of entry for imported refrigerated fish, primarily tilapia from China, whereas Kisumu is a significant consumer in addition to being a producer of freshwater fish.

2.2. Research Design and Survey Instruments

A quasi-longitudinal design was used to collect primary data to assess the influence of covariate shocks and stressors on the fisheries and aquaculture sectors in Kenya. The study's sampling frame was defined as the fish producers in the selected counties. A structured questionnaire was used to collect data from the target respondents. The survey tool comprised three main sections; the first section contained questions on farmer/fisher folk characteristics, household characteristics, and livelihood options. In the second section, the survey questions explored the shocks' occurrence, influence of the shocks on household food security, access to services and markets, and the overall effects on household asset index. The third component of the questionnaire explored the factors influencing household resilience capacities to shocks and the adaptation strategies to help communities to better respond to future shocks.

Quantitative data were completed with qualitative evidence drawn from 20 key informant interviews and 10 community focus group discussions that targeted the targeted fishing communities, including individual fisher folks and aqua-farmers, community groups, county government fisheries and aquaculture officials, community leaders, beach management units (BMUs), and fish traders.

The questionnaire was loaded into Kobo Collect survey platform. Selection of the respondents involved (a) random selection of 10% of the total fish-landing sites found in the four regions and (b) stratified random sampling of individual traders and fisher folks from the selected fish-landing locations. The allocation of sample size to landing sites was proportional to the number of regional actors.

2.3. Sample Size Determination

The sample size was calculated using the formula documented by [24]. According to [24], at 95% confidence level and 50% target population assumed to have characteristics of interest with a Z-statistic of 1.96, the sample size was calculated using the following formula:

$$n = \frac{N}{1 + Np^2}$$

where n = desired sample size

N = population size

p = 0.05

From the available statistics compiled by the Kenya Marine Fisheries Research Institute (https://www.kmfri.go.ke/; accessed on 8 December 2020), it is estimated that the fisheries and aquaculture sectors in the target locations employ approximately 48,000 fisher folks. Using this number, the sample size was drawn as follows:

$$n = 48{,}000/(1 + (48{,}000 \times (0.05 \times 0.05)))$$

The final sample was boosted by 6%; thus, the total number of respondents to the survey was 419.

2.4. Statistical Data Analysis

Data analysis was performed using IBM SPSS version 22 as well as NVivo version 12 for Windows. The qualitative data were inventoried, organized thematically using an iterative and inductive strategy, and analyzed using the Windows version of NVivo software. The secondary data analysis included document extracts captured to preserve the original content and context.

Analysis involved computing the resilience index measurement and analysis (RIMA-II) model to yield a composite resilience capacity index (RCI) indicator. RIMA-II yields RCI, a composite indicator for measuring household resilience based on a combination of observed household factors that often depend on context. These variables are organized into four pillars of RIMA: access to basic services, assets, social safety nets, and adaptive capacity. The estimation of RCI involved a two-step process. The resilience pillars were estimated from observed variables using factor analysis (FA) in the first phase.

The Kaiser–Meyer–Olkin (KMO) test was used to determine whether the index components are suitable for factor analysis. The measure ranges from 0 to 1; high values indicate that the variables are correlated and that the analysis is feasible, whereas KMO values of less than 0.5 are regarded as unacceptable.

The RCI was calculated from the pillars using the multiple indicators multiple causes (MIMIC) model accounting for the food security indicators, food consumption scores (FCS), and food insecurity experience scale (FIES).

The latent variable "resilience" was measured using the MIMIC model. The model comprised two parts: the measurement Equation (1) shows that observable indices of food security are not ideal predictors of resilience capacity; and the structural Equation (2) links estimated characteristics to resilience.

$$\begin{bmatrix} HDD \\ HFIAS \end{bmatrix} = [\gamma 1\ \gamma 2][RCI] + [\varepsilon 1\ \varepsilon 2] \tag{1}$$

$$\mathrm{RCI} = [\beta_1\ \beta_2\ \beta_3\ \beta_4] \begin{bmatrix} ABS \\ AST \\ SSN \end{bmatrix} + [\varepsilon_3] \tag{2}$$
$$\dot{A}C$$

where *ABS*—access to basic services; *AST*—assets; *SSN*—social safety nets; *AC*—adaptive capacity.

Analysis of covariance (ANCOVA) and OLS-censored regression analysis were used to identify determinants of resilience index, as shown in Equation (3):

$$\mathrm{RCI}_i = \beta_0 + \beta_1 \mathrm{Covid}_i, + \beta_2 \mathrm{Climatic\ variability} + \beta_3 \mathrm{Geopolitical\ instability} + \beta_4\ \mathrm{age}_i + \beta_5 \mathrm{female}_i + \beta_6 \mathrm{education}_i + \beta_7 \mathrm{hhsize}_i + \varepsilon_i \tag{3}$$

where RCI is the measure of resilience index. A fixed-effects model was conducted to control for unobserved heterogeneity, keeping in mind the potential heterogeneity in regional resilience. To remedy any potential heteroskedasticity, robust standard errors were used.

3. Results

3.1. Descriptive Analysis

The survey sample comprised the following: fisher folks (n = 201, 48%), pond farmers (n = 54, 13%), cage farmers (n = 30, 7%), and fish traders (n = 134, 32%) (Table 1). The functions performed within the different nodes of the value chain were found to be gender-specific, with more than 95% of men being at the production level and women (88%) performing trade-related activities.

Table 1. Descriptive statistical analysis of the household data.

	Frequency	Percent
Sampledistribution by county		
Kisumu	124	29.6
Busia	105	25.1
Mombasa	91	21.7
Kilifi	99	23.6
Gender of the respondents		
Male	267	63.7
Female	152	36.3
Mainfunction performed in the fish value chain		
Fishing	201	48
Pond farming	54	13
Cage farming	30	7
Fish trade	134	32
Householdincome		

	Male-headed		Female-headed		Total		*p*-value
	n	**%**	***n***	**%**	***n***	**%**	
Numberof HH income sources							**0.03**
None	1	0.3	0	0.0	1	0.2	
One	189	56.1	61	74.4	250	59.7	
Two and more	147	43.6	21	25.6	168	40.1	
Medianmonthly household income from all sources (KES)	18,000		10,000				**<0.001**

Source: Study primary data.

Male-headed households reported higher numbers of income sources compared with female-headed households. This difference was statistically significant ($p < 0.05$). The proportion of male- and female-headed households who had two or more income sources was 43.6% and 25.6%, respectively. In addition, the median monthly household income for male-headed households (KES 18,000) was higher than that of female-headed households (KES 10,000), and the difference was statistically significant ($p < 0.005$).

3.2. Effects of Covariate Shocks on Fish-Dependent Households

Households affected by climate-induced shocks (drought and floods) experienced more than 60% reduction in fish catch and incomes, whereas shocks that disrupted the main supply chains (COVID-19 and geopolitical instability) experienced limited access to markets and inputs, fish prices, and incomes, as reported by more than 74% of affected households. Households that reported not engaging in fishing activities in certain months due to climatic shocks were significantly less likely to recover from shocks compared with those conducting fishing throughout the year (OR = 0.105, 95% CI [0.014, 0.773], $p = 0.027$).

For shocks that disrupted supply chains, the study suggests that households that lacked guaranteed market access were less likely to recover from COVID-19 and geopolitical instability (OR = 0.401, 95% CI [0.161, 0.999], $p = 0.05$). Another significant finding from the analysis was the association between access to inputs and COVID-19 recovery among households. The results indicate that households who had no access to necessary inputs were significantly less likely to recover from COVID-19 compared with those with access (OR = 0.31, 95% CI [0.099, 0.97], $p = 0.044$).

3.3. Determinants of Household Resilience Capacity Index

The Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity were performed to assess the adequacy of the data for factor analysis. The KMO value obtained was 0.598, indicating that the variables have some degree of commonality, though it could be improved. Bartlett's test of sphericity was significant (chi-square = 2489.573, df = 276, $p < 0.001$), confirming that the variables are sufficiently correlated for factor analysis (Table 2).

Table 2. KMO and Bartlett's tests to assess adequacy of the data for factor analysis.

KMO and Bartlett's Test		
Kaiser–Meyer–Olkin Measure of Sampling Adequacy.		0.598
Bartlett's Test of Sphericity	Approx. chi-square	2489.573
	df	276
	Sig.	0.000

Source: Study primary data.

The PCA analysis identified 10 factor variables that potentially influenced households' resilience to covariate shocks. Each variable was loaded onto these components, indicating their contribution to each factor. The factors extracted were then analyzed to generate a household resilience score ranging from 0 to 100. Higher scores indicate higher levels of household resilience. The following factor variables were regressed to assess their influence on household resilience capacity index: number of income sources; total household income; possession of insurance; years of experience; membership in a fish SACCO and access to credit; access to markets, inputs, and training; effect of various shocks (COVID-19, floods, political instability, and drought) on household stability; ownership of assets; and food security index scores (Table 3).

Table 3. Principal components.

Variable	**Component**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Number of HH income sources	0.007	−0.05	−0.003	0.342	−0.064	0.029	−0.053	0.246	**−0.603**	−0.191
Total income	−0.059	0.052	0.007	0.042	−0.002	**0.857**	−0.024	0.142	−0.058	−0.01
Years of experience	0.215	−0.053	0.032	−0.071	0.212	0.052	0.092	0.071	−0.046	**0.775**
Income from fish	−0.057	0.011	−0.048	−0.071	−0.068	**0.833**	0.083	−0.081	0.142	−0.031
Market guaranteed	0.193	−0.088	0.007	0.158	0.07	0.116	−0.054	0.124	0.769	−0.109
Good performance	−0.287	−0.006	−0.037	−0.002	−0.196	−0.118	−0.106	−0.045	0.069	0.61
Belongs to fish SACCO	0.01	−0.097	0.106	0.501	0.03	0.042	**0.688**	0.062	0.16	0.086
Access to inputs	0.036	−0.161	−0.029	**0.653**	0.123	0.147	−0.046	−0.079	−0.196	0.091
Access to markets	0.057	0.026	−0.079	**0.591**	−0.048	−0.134	0.135	0.011	0.039	−0.219
Access to training	−0.044	0.05	0.031	**0.737**	−0.158	−0.034	0.017	0.014	0.07	0.027
Access to credit	−0.041	0.08	−0.027	−0.042	0.048	0.035	**0.886**	0.069	−0.089	−0.048
COVID-19	0.059	0.2	0.081	−0.139	**0.807**	−0.019	0.072	0.009	−0.035	0.063
Recovered from COVID-19	−0.043	0.03	0.023	0.018	**0.871**	−0.052	−0.002	−0.03	0.139	−0.016
Floods	0.161	0.011	**0.83**	−0.085	0.017	−0.022	0.098	−0.101	−0.127	−0.116
Fishing affected by flood	0.114	0.026	**0.888**	−0.019	0.036	−0.054	0.076	−0.143	−0.004	−0.035
Recovered from flood	−0.008	0.023	**0.723**	0.058	0.059	0.036	−0.17	0.186	0.167	0.182
Droughts	**0.846**	0.133	0.102	−0.048	−0.061	−0.061	0.063	−0.019	−0.037	−0.006
Fishing affected by drought	**0.916**	0.002	0.073	0.008	−0.017	−0.009	0.014	−0.005	0.064	0.003
Recovered from drought	**0.782**	−0.065	0.08	0.085	0.106	−0.067	−0.128	−0.045	0.148	−0.015
Political dynamics	0.102	**0.805**	−0.06	−0.051	0.044	0.046	−0.061	−0.091	−0.246	−0.09
Fish affected by political instability	0.062	**0.89**	0.016	−0.04	0.093	0.049	0.05	−0.01	0.024	−0.054

Table 3. *Cont.*

Variable	Component									
	1	2	3	4	5	6	7	8	9	10
Recovered from political instability	−0.087	**0.759**	0.092	0.013	0.089	−0.024	0.04	0.155	0.13	0.079
Savings	0.054	0.068	−0.1	0.014	0.224	0.027	0.066	**0.771**	−0.053	−0.03
Support system	−0.124	−0.013	0.022	−0.044	−0.306	0.037	0.047	**0.697**	0.038	0.065

Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalization. A rotation converged in eight iterations. Factor components with eigen values >0.5 (in bold) meant the independent variables sufficiently accounted for variance in the household resilience capacity index.

Descriptive statistics were obtained for the generated household index score in a range of 0–100. The results indicate that the mean household index score for male-headed households (mean = 45.07 ± 10.43) was superior to that of female-headed households (mean = 38.15 ± 9.25) (Table 4).

Table 4. RCI scores between male-headed and female-headed households.

Descriptive Statistics						
Male- or Female-Headed HH		*n*	Min	Max	Mean	SD
Male-headed	Household resilience capacity index	335	24.00	80.00	45.07	10.43
	Valid N (listwise)	335				
Female-headed	Household resilience capacity index	82	22.00	62.00	38.15	9.25
	Valid N (listwise)	82				

Source: Study primary data.

Furthermore, the resilience scores were analyzed across different counties. The mean resilience scores varied across counties, with Kisumu having a mean score of 44.62, Busia of 42.95, Mombasa of 45.27, and Kilifi of 41.98. These differences indicate variations in the social resilience capacities among households in different regions. The RCI scores were higher in the urban areas (Mombasa and Kisumu), and this was attributed to such households' ability to engage in non-production casual-labor-related income-generating activities during off-fishing seasons (Table 5).

Table 5. RCI scores by study location.

Descriptive Statistics						
County		*n*	Min	Max	Mean	SD
Kisumu	Household resilience capacity score	123	26.00	80.00	44.6179	11.14768
	Valid N (listwise)	123				
Busia	Household resilience capacity score	105	22.00	68.00	42.9524	9.73928
	Valid N (listwise)	105				
Mombasa	Household resilience capacity score	90	24.00	80.00	45.2667	11.11513
	Valid N (listwise)	90				
Kilifi	Household resilience capacity score	99	22.00	74.00	41.9798	9.96932
	Valid N (listwise)	99				

Source: Study primary data.

Figure 1 shows the resilience capacity index (RCI) by value chain (VC) actor. The mean RCI was 44.89 (SD = 10.09) for households that performed fishing (n= 201), 44.04 (SD = 12.07) for pond farming (n = 53), 48.60 (SD = 10.47) for cage farming (n = 30), and 40.71 (SD = 9.97) for fish trading (N = 133).

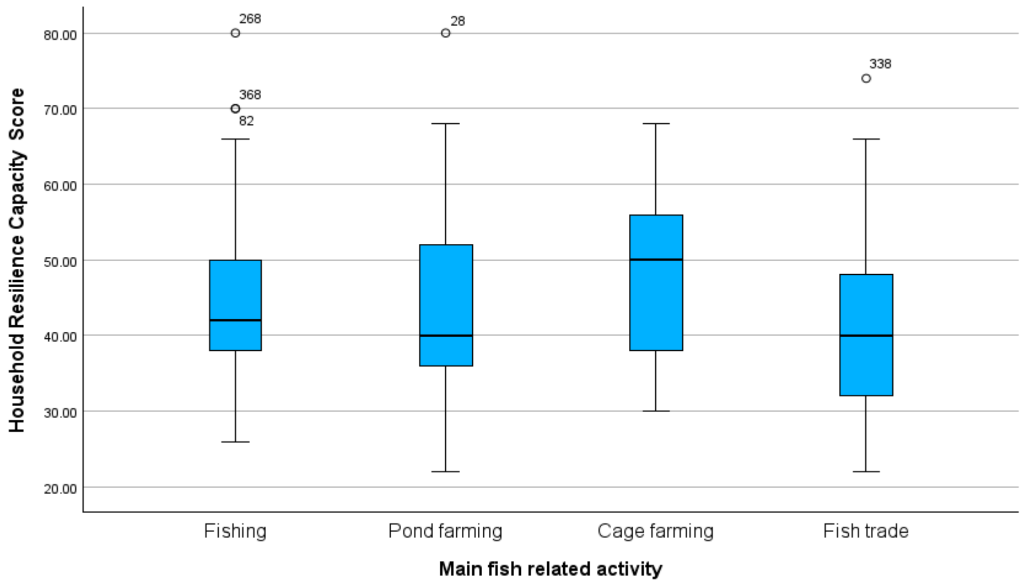

Figure 1. Resilience capacity index by value-chain actor. Note: Outliers above the box plot are assigned random numbers of observations in the dataset.

The Tukey post hoc test results for the resilience capacity index (RCI) by value chain (VC) actor indicate that there are significant differences between the groups. Fish trade (n = 133) had a mean RCI of 40.71, significantly different from cage farming (n = 30), which had the highest mean RCI of 48.60 (p < 0.005). Pond farming (n = 53) and fishing (n = 201) had intermediate mean RCIs of 44.04 and 44.89, respectively, and were not significantly different from each other (Table 6). Cage farming is an emerging climate-smart technology that enables fish-dependent households to sustain production even during shocks.

Table 6. Tukey post hoc for the RCI by value-chain actor.

Tukey B [a,b]				
Function in the VC	n	Subset for alpha = 0.05		p-value
		1	2	
Fish trade	133	40.7068		
Pond farming	53	44.0377	44.04	
Fishing	201	44.8856	44.89	
Cage farming	30		48.60	<0.005
Means for groups in homogeneous subsets are displayed.				

[a] Uses harmonic mean sample size = 61.828. [b] The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed. *Source: Study primary data.*

3.4. Factors Influencing Households' Resilience Capacities to Shocks

The ordinal least squares (OLS) model was used to analyze the factors influencing household resilience capacities to shocks in the Kenyan fisheries and aquaculture sectors. The coefficient for male- or female-headed households was −4.843 and was found to be statistically significant (p = 0.006). This negative coefficient suggested that being a female-headed household is associated with lower resilience capacities compared with male-headed households. The coefficient for the number of incomes was 3.64, and it is statistically significant (p = 0.001). This positive coefficient indicates that households with a higher number of income sources tend to have higher resilience capacities. Other factors, including access to credit, levels of income, and availability of support systems/safety nets positively contributed to the household resilience capacity index (Table 7).

Table 7. Regression OLS model.

	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	*p*-Value
Level of education	0.403	0.943	0.029	0.428	0.67
Male- or female-headed HH	−4.843	1.746	−0.187	−2.774	0.006
Number of incomes	3.64	1.044	0.241	3.488	0.001
Income level	0.00	0.000	0.405	6.378	0.000
Credit access	−2.55	1.512	−0.122	−1.684	0.004
Function performed in the VC	−1.49	0.649	−0.182	−2.288	0.023
Access to inputs	−2.55	1.668	−0.102	−1.530	0.128
Regular savings	−1.717	2.054	−0.058	−0.836	0.405
Presence of support system/safety net	−2.954	1.563	−0.131	−1.89	0.41
Food security status	−0.279	0.158	−0.148	−1.764	0.08

Source: Study primary data.

4. Discussion

In this study, we measured the household resilience capacities to shocks among fish value-chain actors and assessed the determinants of household resilience capacities. The study started by analyzing the effect of gender on household resilience capacities, which is very important because in sub-Saharan Africa, women play a significant role in food security and adapting to covariate shocks at the household level [25]. The present study shows a significant difference in the household resilience index scores between male-headed and female-headed households in the Kenyan fisheries and aquaculture sectors. The mean resilience index score for male-headed households was higher than that for female-headed households. The negative coefficient for male- or female-headed households (−4.843, $p = 0.006$) indicates that female-headed households exhibit significantly lower resilience than male-headed households. This suggests that male-headed households are more likely to withstand and recover from shocks than their female-headed counterparts. This could be attributed to several factors contributing to these gender disparities in resilience capacities. Male-headed households typically have better access to financial resources, credit facilities, and ownership of land and fishing equipment [26]. These resources provide a buffer during economic or environmental shocks, facilitating quicker recovery. In contrast, female-headed households often face barriers to accessing financial services and owning productive assets. Cultural norms and gender discrimination also limit women's economic opportunities, reducing their ability to respond effectively to shocks.

This finding is consistent with previous studies, which have shown that female-headed households often face more significant socio-economic challenges, including limited access to resources and economic opportunities, reducing their resilience [27–31]. These households may have less access to capital, credit, and support networks, making it harder to cope with and recover from shocks. Additionally, female-headed households might experience more significant barriers in accessing markets and receiving fair prices for their produce, further impacting their economic stability and resilience [32]. These results corroborate [33] study which also reports the high resilience of male-headed households compared with female-headed households. Ref. [33] argues that women in male-headed households are mainly responsible for looking after the children, while their husbands are primarily responsible for aquaculture production, with support from their wives and some sub-activities such as input collection and feeding. Women in female-headed households have domestic and productive roles, and sometimes they have to hire men to assist them, since some activities demand physical strength. This increases their vulnerability to shocks compared with male-headed households primarily focusing on production. Additionally, research from various developing countries echoes the gender disparity in resilience capacity, highlighting the need for targeted interventions to support female-headed households [34]. These interventions could include improving access to credit, training, and market opportunities specifically for female-headed households to enhance their economic stability and resilience.

The household resilience capacity scores across the four counties in Kenya—Kisumu, Busia, Mombasa, and Kilifi—indicate how well households in these regions can withstand and recover from covariate shocks. The higher resilience scores in Mombasa and Kisumu might be attributed to better access to resources, diversified income sources, and more robust support systems than in Busia and Kilifi. The variation in resilience capacity scores can be attributed to several factors. Economic diversification is one significant factor. Regions with higher economic diversification tend to have higher resilience. Mombasa, a major coastal city with diverse economic activities beyond fisheries, might provide households with more opportunities to diversify their income sources. This diversification reduces vulnerability to sector-specific shocks [35]. Access to markets, credit, and training resources significantly impacts resilience. Counties like Kisumu and Mombasa, which are more urbanized and economically vibrant, have better access to these resources. More robust social support networks can enhance resilience by providing a safety net during shocks. Mombasa's relatively high score could reflect better social cohesion and support systems, which are crucial during times of crisis. Coastal regions like Mombasa and Kilifi face unique environmental challenges, such as rising sea levels and frequent storms. However, Mombasa's higher score suggests that households might be better equipped to cope despite these challenges, possibly due to more effective local governance and disaster-preparedness programs [36]. The findings of this study are consistent with previous research by [37] in Malawi, which found that households with diversified income sources and better resource access demonstrated higher resilience. Similarly, a study by [38], drawing examples from South Asian countries, highlighted the critical role of financial inclusion and social support in enhancing resilience. A study by [39] also emphasized the importance of access to credit and training programs in building resilience. These studies support the observation that regions with better access to economic opportunities and social support networks tend to exhibit higher resilience scores.

The number of income sources emerges as a significant positive factor (coefficient = 3.64, $p = 0.001$), indicating that households with diversified income streams are better equipped to withstand shocks. This aligns with the literature suggesting that income diversification enhances resilience by providing multiple avenues for financial stability, thereby mitigating the impact of sector-specific disruptions [40,41]. Diversified income sources can buffer against shocks, as losses in one area can be compensated by gains in another, thus stabilizing the overall household income. This is particularly relevant in the Kenyan fisheries and aquaculture sectors, where shocks such as frequent droughts and seasonal floods, the COVID-19 pandemic, and national geopolitical instability can be significant [42,43], in a study on shocks, recovery trajectories, and resilience among aquaculture-dependent households, supported the present results by noting that diversification provides critical adaptive capacity to various unforeseen shocks [44], with evidence from small-scale aquaculture agriculture systems in Myanmar, also note that diversification strategies have a stabilizing effect on income and food availability during livelihood shocks such as COVID-19. Similarly, household resilience to food insecurity increases with the increasing diversity of livelihood. The present results are also confirmed by [45] study, which confirms the crucial role of livelihood diversification in improving household resilience to food insecurity in higher- and lower-wealth groups.

Despite being hypothesized as a potential resilience factor, the education level did not significantly impact household resilience capacity in this study (coefficient = 0.403, $p = 0.67$). This finding contradicts previous research, such as [46], which reported that the household head's education level significantly impacts household resilience capacities. Similarly, Ref. [47] documented that higher levels of education complement other drivers, enhancing the implementation of techniques to improve resilience against climate variability and change. The insignificance of education in the present study may be attributed to several factors. While education generally enhances long-term adaptive capacities, its immediate effects on resilience to sudden shocks may not be as pronounced. Educated individuals may be better at long-term planning and resource management, but this does not necessarily translate into immediate resilience against shocks. Additionally, education's quality and practical relevance may vary, influencing its effectiveness as a resilience factor [47]. It is possible that education systems in the study regions do not sufficiently emphasize practical skills directly applicable to immediate resilience strategies, thereby reducing the observed impact of education on resilience in the short term.

Other variables like increased prices, unplanned illnesses, loss of household members, heavy taxation, sale of assets, possession of insurance, and regular savings also did not show statistically significant impacts on resilience capacities ($p > 0.05$). This lack of significance might reflect the complex interplay of multiple factors influencing resilience, where individual elements alone do not determine overall capacity. For instance, while heavy taxation could theoretically reduce disposable income and affect resilience, households might have adapted to such conditions over time, thus dampening the immediate perceived impact. The presence of a support system, while not statistically significant at the 5% level, shows a p-value of 0.061, suggesting a trend toward significance. This implies that social networks and community support could enhance resilience, although more targeted research is needed to establish this relationship. The present results agree with the study by [48] , which showed that social networks influence the resilience capacities index among fish value-chain actors in Malawi. However, social networks did not significantly affect house resilience during the shock of COVID-19.

Ref. [48] attributed the insignificance of social networks in building resilience capacities to the covariate nature of the COVID-19 shock, which meant that all households were affected. When all households are affected, social networks will not help households attain the desired level of development outcomes. Previous studies have highlighted the importance of social capital in providing emotional, informational, and financial support during crises, which can significantly contribute to household resilience [49]. Support systems can offer immediate help during shocks and contribute to quicker recovery, highlighting their potential importance.

Interestingly, the food insecurity index during and after shocks (FIES during shocks and FIES after shocks) showed coefficients close to zero and were not statistically significant ($p > 0.05$). This result indicates that immediate food insecurity, as measured by the FIES, does not significantly affect overall resilience capacities. This might suggest that households' resilience is more influenced by structural and economic factors than short-term food insecurity metrics. It highlights that addressing broader economic stability and structural issues might be more critical to enhancing resilience than focusing solely on food security during shocks.

The analysis of insurance as a social safety net indicates a significant association between the possession of insurance and the county of residence ($p = 0.014$), with a notably low prevalence of insurance coverage across all four counties studied. Kisumu recorded the highest percentage of households possessing insurance (22.7%), which is still relatively low, followed by Busia (19.0%), Mombasa (14.3%), and Kilifi (7.9%). These figures suggest that insurance coverage as a buffer against economic shocks is not widely adopted among the households in these regions. The low prevalence of insurance could be attributed to several factors, including limited access to insurance services, lack of awareness about the benefits of insurance, and financial constraints that make insurance premiums unaffordable for many households [50,51]. Interestingly, the data showed no significant association between the possession of insurance and whether the household is male- or female-headed ($p = 0.269$). However, more male-headed households (17.2%) had members possessing insurance than female-headed households (12.2%). This disparity might reflect the broader socio-economic challenges female-headed households face, such as lower income levels and reduced access to financial services, which hinder their ability to afford and maintain insurance policies .

The marginally significant association between the possession of insurance and the primary source of income (p = 0.051) suggests that households with different primary income sources may have varying access to and utilization of insurance. The results agree with [52] study , which reported that households relying on less stable income sources might find it harder to allocate resources toward insurance premiums. The mean household size and the mean number of members with an income were not significantly associated with the possession of insurance. This indicates that larger household size or the number of income-earning members does not directly influence the likelihood of possessing insurance. This finding aligns with the idea that insurance adoption is more closely tied to other socio-economic factors, such as education, awareness, and income stability, than household composition alone [53]. Ref. [54] have highlighted the need for more inclusive and accessible insurance products tailored to the needs of low-income households to enhance their resilience to economic shocks.

5. Conclusions

This study highlights the critical factors influencing household resilience capacities in the Kenyan fisheries and aquaculture sectors, revealing significant disparities based on household head gender and income diversity. Male-headed households demonstrated superior resilience to their female-headed counterparts, indicating a gender disparity that needs addressing. The positive correlation between the number of income sources and household resilience underscores the importance of economic diversification in enhancing resilience. While regional differences were noted, with Mombasa showing the highest resilience scores, the influence of education, food insecurity, and other socio-economic factors was not statistically significant. The low prevalence of insurance coverage across all counties indicates a vulnerability that warrants policy intervention. These findings suggest the necessity for targeted support and comprehensive policies to bolster resilience, particularly for female-headed households and regions with lower resilience scores. The study recommends (a) adopting gender-sensitive approaches in fisheries and aquaculture interventions to empower women in trade, (b) strengthening policies to enhance access to and adoption of climate-smart technologies such as fish cage farming, (c) promoting livelihood diversification to sustain households' income during fishing off-seasons, and (d) enhancing market linkages in the fish value chain through coordinated producer organizations. Further research should explore the possibilities of introducing index-based weather insurance and other tested suitable safety nets for the fisheries and aquaculture sector.

Author Contributions: Conceptualization, E.O. and S.O.; methodology, K.O.; validation, S.O. and M.C.; formal analysis, S.O.; investigation, S.O.; data curation, E.O. and K.O.; writing—original draft, S.O. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding, and the APC was funded by the authors.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Maseno University Scientific Ethics Review Committee (protocol code MUSERC/01280/23, 24 October 2023).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The raw dataset used in the analysis is publicly available here: Dataset_Influence_of_Covariate_Shocks_to_Households_Resilience.

Acknowledgments: The authors acknowledge the support of lecturers from Maseno University who provided valuable suggestions in the research design and analysis methods. We also acknowledge the research assistants who supported the data collection and all respondents who participated in the study.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Kimani, E.; Okemwa, G.; Aura, C. The Status of Kenya Fisheries: Towards Sustainability Exploitation of Fisheries Resources for Food Security and Economic Development. Available online: https://aquadocs.org/handle/1834/16123 (accessed on 8 December 2023).
2. Munguti, J.M.; Obiero, K.O.; Iteba, J.O.; Kirimi, J.G.; Kyule, D.N.; Orina, P.S.; Githukia, C.M.; Outa, N.; Ogello, E.O.; Mboya, J.B.; et al. Role of multilateral development organizations, public and private investments in aquaculture subsector in Kenya. *Front. Sustain. Food Syst.* **2023**, *7*, 1208918. [CrossRef]
3. Cheserek, M.; Obiero, K.; Ogello, E. Eat More Fish. *SAMUDRA Rep.* **2021**, *86*, 20–22.
4. Mboya, J.B.; Obiero, K.O.; Cheserek, M.J.; Ouko, K.O.; Ogello, E.O.; Outa, N.O.; Nyauchi, E.A.; Kyule, D.N.; Munguti, J.M. Factors influencing farmed fish traders' intention to use improved fish post-harvest technologies in Kenya: Application of technology acceptance model. *Fish. Aquat. Sci.* **2023**, *26*, 105–116. [CrossRef]
5. Fiorella, K.J.; Bageant, E.R.; Mojica, L.; Obuya, J.A.; Ochieng, J.; Olela, P.; Otuo, P.W.; Onyango, H.O.; Aura, C.M.; Okronipa, H. Small-scale fishing households facing COVID-19: The case of Lake Victoria, Kenya. *Fish. Res.* **2021**, *237*, 105856. [CrossRef] [PubMed]
6. Adekola, O.; Gatonye, M.; Orina, P. Status and Outlook for Climate Resilient Aquaculture in Kenya: Stakeholders Perspectives. *Case Stud. Environ.* **2022**, *6*, 159–197. [CrossRef]
7. Mhlanga, D.; Ndhlovu, E. The Implications of the Russia-Ukraine War on Sustainable Development Goals in Africa. *SSRN Electron. J.* **2022**, *16*, 435–454. [CrossRef]
8. Carrier-Belleau, C.; Drolet, D.; McKindsey, C.W.; Archambault, P. Environmental stressors, complex interactions and marine benthic communities' responses. *Sci. Rep.* **2021**, *11*, 4194. [CrossRef]
9. Abisha, R.; Krishnani, K.K.; Sukhdhane, K.; Verma, A.K.; Brahmane, M.; Chadha, N.K. Sustainable development of climate-resilient aquaculture and culture-based fisheries through adaptation of abiotic stresses: A review. *J. Water Clim. Change* **2022**, *13*, 2671–2689. [CrossRef]
10. Amaru, S.; Chhetri, N.B. Climate adaptation: Institutional response to environmental constraints, and the need for increased flexibility, participation, and integration of approaches. *Appl. Geogr.* **2013**, *39*, 128–139. [CrossRef]
11. Freduah, G.; Fidelman, P.; Smith, T.F. The impacts of environmental and socio-economic stressors on small scale fisheries and livelihoods of fishers in Ghana. *Appl. Geogr.* **2017**, *89*, 1–11. [CrossRef]
12. Tefera, T.D.; Ali, S.F. Impacts of Climate Change on Fish Production and Its Implications on Food Security in Developing Countries. *Int. J. Food Nutr. Res.* **2019**, *3*, 114–135.
13. Alam, G.M.M.; Sarker, M.N.I.; Gatto, M.; Bhandari, H.; Naziri, D. Impacts of COVID-19 on the Fisheries and Aquaculture Sector in Developing Countries and Ways Forward. *Sustainability* **2022**, *14*, 1071. [CrossRef]
14. Nuh, R.; Phetkaew, C.; Zakaria, F. A SWOT—TOWS Analysis for Developing the Strategy of Cage-Based Aquaculture Business in Saiburi, Patani Province. *Asia Soc. Issues* **2023**, *16*, e255078. [CrossRef]
15. Guruswamy, S.; Pojić, M.; Subramanian, J.; Mastilović, J.; Sarang, S.; Subbanagounder, A.; Stojanović, G.; Jeoti, V. Toward Better Food Security Using Concepts from Industry 5.0. *Sensors* **2022**, *22*, 8377. [CrossRef]
16. Devereux, S. The impact of droughts and floods on food security and policy options to alleviate negative effects. *Agric. Econ.* **2007**, *37*, 47–58. [CrossRef]
17. Niles, M.T.; Salerno, J.D. A cross-country analysis of climate shocks and smallholder food insecurity. *PLoS ONE* **2018**, *13*, e0192928. [CrossRef]
18. Béné, C.; Wood, R.G.; Newsham, A.; Davies, M. Resilience: New utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes. *IDS Work. Pap.* **2012**, *2012*, 1–61.
19. FAO. *The State of World Fisheries and Aquaculture*; Food Agricultural Organization of the United Nations: Rome, Italy, 2020.
20. d'Errico, M.; Romano, D.; Pietrelli, R. Household resilience to food insecurity: Evidence from Tanzania and Uganda. *Food Secur.* **2018**, *10*, 1033–1054. [CrossRef]
21. TANGO International. *Resilience Evaluation, Analysis and Learning (REAL) Associate Award*; TANGO International: Washington, DC, USA, 2020.
22. TANGO International. *Resilience and Resilience Capacities Measurement Options: Full Approach—Household Questionnaire*; TANGO International: Washington, DC, USA, 2018.
23. Brück, T.; d'Errico, M.; Pietrelli, R. The effects of violent conflict on household resilience and food security: Evidence from the 2014 Gaza conflict. *World Dev.* **2019**, *119*, 203–223. [CrossRef]
24. Fisher, R.A. The logic of inductive inference (with discussion). *J. R. Stat. Soc.* **1935**, *98*, 39–82. [CrossRef]
25. Nellemann, C.; Verma, R.; Hislop, L. (Eds.) Women at the frontline of climate change: Gender risks and hopes. In *A Rapid Response Assessment*; GRID-Arendal; United Nations Environment Programme: Nairobi, Kenya, 2011.
26. Kiumbuku, S.; Mutinda, J.; Bernard, J. Forms of gender inequalities in fish farming in Kwnza Division, Trans Nzoia County, Kenya. *Res. Humanit. Soc. Sci.* **2013**, *15*, 1–9.
27. Omolo, N.; Mafongoya, P.; Ngesa, O.; Voi, K. Gender and Resilience to Climate Variability in Pastoralists Livelihoods System: Two Case Studies in Kenya. *J. Sustain. Dev.* **2017**, *10*, 218. [CrossRef]
28. Agarwal, B. Gender equality, food security and the sustainable development goals. *Curr. Opin. Environ. Sustain.* **2018**, *34*, 26–32. [CrossRef]

29. Doss, C.; Kovarik, C.; Peterman, A.; Quisumbing, A.; Van Den Bold, M. Gender inequalities in ownership and control of land in Africa: Myth and reality. *Agric. Econ.* **2015**, *46*, 403–434. [CrossRef]
30. Fuller, R.; Lain, J. Are female-headed households less resilient? Evidence from Oxfam's impact evaluations. *Clim. Dev.* **2020**, *12*, 420–435. [CrossRef]
31. Appiah, S.; Antwi-Asare, T.O.; Agyire-Tettey, F.K.; Abbey, E.; Kuwornu, J.K.; Cole, S.; Chimatiro, S.K. Livelihood vulnerabilities among women in small-scale fisheries in Ghana. *Eur. J. Dev. Res.* **2021**, *33*, 1596–1624. [CrossRef]
32. Mwaura, J.M. An Assessment of Status and Determinants of Food Security in Female-Headed Households in Nairobi County. Ph.D. Thesis, University of Nairobi, Nairobi, Kenya, 2022.
33. Nguyen, T.T.H. *Vulnerability and Adaptation of Women Aquaculturalists to Climate Change: A Case Study of Women in Small-Scale Aquaculture in Tien Hai District, Thai Binh, Vietnam*; Regional Center for Social Science and Sustainable Development: Chiang Mai, Thailand, 2018.
34. Quisumbing, A.; Cole, S.; Elias, M.; Faas, S.; Galiè, A.; Malapit, H.; Meinzen-Dick, R.; Myers, E.; Seymour, G.; Twyman, J. *Measuring Women's Empowerment in Agriculture: Innovations and Evidence. Background Paper for The Status of Women in Agrifood Systems, Nairobi, Kenya, CGIAR GENDER Impact Platform*; CGIAR: Montpellier, France, 2023; Available online: https://hdl.handle.net/10568/129707 (accessed on 25 August 2024).
35. Martini, B. Resilience, reorientation and variety: An analysis of Italian provinces after the 2007 economic shock. In *Resilience, Crisis and Innovation Dynamics*; Edward Elgar Publishing: Cheltenham, UK, 2018; pp. 211–230.
36. Okaka, F.O.; Odhiambo, B.D. Health vulnerability to flood-induced risks of households in flood-prone informal settlements in the Coastal City of Mombasa, Kenya. *Nat. Hazards* **2019**, *99*, 1007–1029. [CrossRef]
37. Alinovi, L.; D'errico, M.; Mane, E.; Romano, D. Livelihoods strategies and household resilience to food insecurity: An empirical analysis to Kenya. *Eur. Rep. Dev.* **2010**, *1*, 1–52.
38. Hussain, A.B.; Islam, M.; Ahmed, K.J.; Haq, S.M.A.; Islam, M.N. Financial Inclusion, Financial Resilience, and Climate Change Resilience. In *Handbook of Climate Change Management: Research, Leadership, Transformation*; Springer International Publishing: Cham, Switzerland, 2021; pp. 2085–2107.
39. Ramilan, T.; Kumar, S.; Haileslassie, A.; Craufurd, P.; Scrimgeour, F.; Kattarkandi, B.; Whitbread, A. Quantifying farm household resilience and the implications of livelihood heterogeneity in the semi-arid tropics of India. *Agriculture* **2022**, *12*, 466. [CrossRef]
40. Ellis, F. *Rural Livelihoods and Diversity in Developing Countries*; Oxford University Press: New York, NY, USA, 2000.
41. Cochrane, L.; Cafer, A. Does diversification enhance community resilience? A critical perspective. *Resilience* **2018**, *6*, 129–143.
42. Mills, D.J.; Adhuri, D.S.; Phillips, M.J.; Ravikumar, B.; Padiyar, A.P. Shocks, recovery trajectories and resilience among aquaculture-dependent households in post-tsunami Aceh, Indonesia. *Local Environ.* **2011**, *16*, 425–444. [CrossRef]
43. Obiero, K.O.; Waidbacher, H.; Nyawanda, B.O.; Munguti, J.M.; Manyala, J.O.; Kaunda-Arara, B. Predicting Uptake of Aquaculture Technologies Among Smallholder Fish Farmers in Kenya. *Aquac. Int.* **2019**, *27*, 1689–1707. [CrossRef]
44. Wang, Q.; Rossignoli, C.M.; Dompreh, E.B.; Su, J.; Griffiths, D.; Htoo, K.K.; Nway, H.M.; Akester, M.; Gasparatos, A. Diversification strategies have a stabilizing effect for income and food availability during livelihood shocks: Evidence from small-scale aquaculture-agriculture systems in Myanmar during the COVID-19 pandemic. *Agric. Syst.* **2024**, *217*, 103935. [CrossRef]
45. Kasie, T.A. Household Resilience to Food Insecurity: Shock Exposure, Livelihood Strategies & Risk Response Options. Ph.D. Thesis, University of Jaume I, Castellón de la Plana, Spain, 2017.
46. Smith, L.C.; Frankenberger, T.R. Does resilience capacity reduce the negative impact of shocks on household food security? Evidence from the 2014 floods in Northern Bangladesh. *World Dev.* **2018**, *102*, 358–376. [CrossRef]
47. Kom, Z.; Nethengwe, N.S.; Mpandeli, N.S.; Chikoore, H. Determinants of small-scale farmers' choice and adaptive strategies in response to climatic shocks in Vhembe District, South Africa. *GeoJournal* **2022**, *87*, 677–700. [CrossRef]
48. Chiwaula, L.S.; Chirwa, G.C.; Simbeye, J.; Katundu, M. Household resilience among fish value chain actors during the COVID-19 pandemic in Malawi. *World Dev. Perspect.* **2022**, *26*, 100411. [CrossRef]
49. Aldrich, D.P.; Meyer, M.A. Social capital and community resilience. *Am. Behav. Sci.* **2015**, *59*, 254–269. [CrossRef]
50. Packard, T.; Gentilini, U.; Grosh, M.; O'keefe, P.; Robalino, D.; Santos, I. *Protecting All: Risk Sharing for a Diverse and Diversifying World of Work*; World Bank Publications: Washington, DC, USA, 2019.
51. Chantarat, S.; Mude, A.G.; Barrett, C.B.; Carter, M.R. Designing index-based livestock insurance for managing asset risk in northern Kenya. *J. Risk Insur.* **2013**, *80*, 205–237. [CrossRef]
52. Bundorf, M.K.; Pauly, M.V. Is health insurance affordable for the uninsured? *J. Health Econ.* **2006**, *25*, 650–673. [CrossRef]
53. Lusardi, A.; Michaud, P.C.; Mitchell, O.S. Optimal financial knowledge and wealth inequality. *J. Political Econ.* **2017**, *125*, 431–477. [CrossRef]
54. Meng, Q.; Yuan, B.; Jia, L.; Wang, J.; Yu, B.; Gao, J.; Garner, P. Expanding health insurance coverage in vulnerable groups: A systematic review of options. *Health Policy Plan.* **2011**, *26*, 93–104. [CrossRef] [PubMed]