Compound Vulnerability and Food Security in Somalia

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Abstract

This study[1] uses FAO Data in Emergencies (DIEM) survey data from 5,396 households to examine compound vulnerability and food security in Somalia. These households have experienced a variety of simultaneous shocks, including economic, agricultural, natural, conflict-related, and idiosyncratic occurrences. This study precisely measured these shocks using both parametric and non-parametric Multi-Shock Indices. Cumulative shock exposure was low to moderate on average (13.3–14.6 percent of the maximum achievable), but there was a sizable minority at high levels of exposure: 1,142 households surpassed mean-plus-one standard deviation under the parametric MSI, while 1,350 households exceeded the 75th percentile using the non-parametric MSI. High-risk households were concentrated within vulnerable socio-demographic categories (e.g., female-headed households, less educated household heads, and displaced households) and within certain regions (e.g., Woqooyi Galbeed, Lower Shabelle, and Mudug). Inadequate food security outcomes, such as lower Food Consumption Scores, inadequate dietary diversity, and the use of crisis or emergency coping mechanisms, were closely linked to high MSI values. The parametric MSI also indicated a non-linear amplification for greater levels of cumulative exposure; specific combinations of shocks, such as increasing food prices with animal disease or lost work, had particularly powerful, detrimental impacts. In order to help vulnerable households before shocks occur, these findings emphasize the significance of shock-sensitive and tailored interventions that connect numerous shock indicators to traditional food insecurity measures.

Keywords: Multi-Shock Index, compound vulnerability, non-parametric and parametric sub-indices, household, food security

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[1] IFPRI Food Security Portal Small Grants Research Agenda Using DIEM Data for African Countries, Source of data: FAO. 2025. Somalia: DIEM-Monitoring assessments results (September and 2025). In: FAO Data in Emergencies Hub. Rome. September 2025, https://data-in-emergencies.fao.org

Background and Context

Food security in Africa south of the Sahara is jeopardized by a multifaceted and evolving array of overlapping shocks, including drought, flooding, rising food prices, public health emergencies, and conflict. These factors contribute to complex vulnerabilities that hinder lower socioeconomic classes from adequately and safely accessing physical, social, and economic benefits and nutritious food. Somalia continues to experience particularly severe food insecurity as a result of ongoing droughts, violence, and economic instability.

Climate shocks and environmental deterioration are particularly dangerous in Somalia because almost 70 percent of the country's population depends on rain-fed agriculture and pastoralism (UNICEF, 2024; FSNAU, 2025). Large-scale droughts, especially those seen from 2020 to 2023, and the locust outbreak in 2020–2021 have severely damaged crops and livestock that are essential to the nation's economy and way of life (FAO, 2024; FSNAU, 2024; World Bank, 2024). In fact, due to local product loss and shocks to the global supply chain, local prices of rice, sorghum, and maize jumped by 10 percent, 30 percent, and 25 percent, respectively, in 2022 (World Bank, 2022; FAO, 2024). As a result, almost 1.5 million children under the age of five are at risk of acute malnutrition, and around 8.3 million people—nearly half of Somalia's population—need humanitarian relief each year (OCHA, 2024).

In addition, more than 3.8 million Somalis have reportedly been displaced due to ongoing instability, which has mostly been caused by Al-Shabaab. This instability also impedes the delivery of humanitarian relief and affects agricultural productivity, supply chains, and market access (UNHCR 2024; OCHA 2024; WFP 2025).

Finally, pastoral communities are particularly vulnerable to resource poverty, gender-based violence, and illness, with women and children in displacement camps especially at risk (FSNAU, 2025; UNICEF, 2024; WFP, 2025).

Thus, Somalia continues to have a risk profile that reflects the exacerbation of environmental, political, and economic crises in addition to persistent food insecurity and pressing humanitarian needs (FAO, 2024; OCHA, 2024). In rural, agro-pastoral, and vulnerable populations in particular, the simultaneous emergence of several interrelated shocks—climate extremes, conflict, economic volatility, and health emergencies—creates synergistic consequences that worsen food insecurity and impede recovery (World Bank, 2024). Due to their multifaceted and system-related nature, these shocks are not mutually exclusive, and their cumulative effects create results that are noticeably more severe than the sum of their individual effects (FAO, 2022). Rural and vulnerable communities are disproportionately affected by this cyclical and reinforcing interaction of shocks, which prolongs systemic vulnerability and delays recovery due to lack of access to resources and social protection systems (FSNAU, 2024; OCHA, 2024).

Several studies show how Somalia's lengthy conflict has negatively impacted household food security through market disruptions, asset depletion, displacement, and limited access to humanitarian aid (FSNAU, 2024; Hassan et al., 2022; Mohamed & Aden, 2023). However, there are still significant gaps in this vast collection of work. In terms of methodology, the majority of research utilizes binary or average shock indicators and cross-sectional survey methods, which do not adequately represent the cumulative, interacting, and recurring character of shocks that households experience (Dercon, 2004; Hoddinott & Quisumbing, 2010). Conceptually, shocks are frequently studied in a compartmentalized way, with distinct strands concentrating on shocks related to conflict (Hassan et al., 2022; Mohamed & Aden, 2023), climate stressors (Abdi et al., 2021; FAO, 2024), or economic disruptions (Farah et al., 2024), while ignoring how these shocks overlap and compound. Because of this, parametric and non-parametric multi-shock metrics that can identify clustering and extreme vulnerability are rarely applied or compared in previous studies, which limits their applicability for directing food security programming in Somalia. The majority of studies assume linear relationships between shocks and food security outcomes, ignoring potential non-linear or threshold effects (Carter et al., 2007; Barrett et al., 2021), and empirical coverage is still uneven in terms of geography and context (Ali & Yusuf, 2023; Farah et al., 2024; Ibrahim et al., 2023).

Furthermore, the compounded risks faced by female-headed households, displaced populations, and marginalized clans are not well understood because structural vulnerabilities like gender, education, displacement status, and marginalization are often treated as control variables rather than as determinants of repeated shock exposure (Ali & Yusuf, 2023; Maxwell et al., 2014; World Bank, 2020). Therefore, in situations of chronic and multifaceted food insecurity, the literature currently in publication offers little guidance for region-specific targeting, identifying extreme vulnerability, and designing tiered policies that differentiate between preventive interventions and high-intensity humanitarian responses.

This study closes a number of important gaps in the body of knowledge regarding food insecurity in Somalia and other precarious, conflict-affected environments. By clearly capturing the cumulative, interacting, and overlapping nature of shocks, it first goes beyond the prevalent single-shock and additive frameworks and shows how extreme food insecurity is driven by clustering exposure rather than average shock occurrence. By creating and contrasting parametric and non-parametric Multi-Shock Indices (MSI), it further advances measurement by demonstrating how various architectures produce diverse policy-relevant insights and uncover unique vulnerability profiles. Third, instead of depending on a single outcome indicator, the study connects multi-shock exposure to several aspects of food insecurity, such as dietary quality, hunger intensity, and coping mechanisms. Fourth, it reveals threshold dynamics that are missed in linear models by exposing non-linear and interaction effects between shocks. Lastly, it allows for region-specific and tiered policy targeting that separates preventive interventions from high-intensity humanitarian responses by incorporating structural features like gender, displacement status, household education, and type of livelihood into the analysis of compounded vulnerability.

This study's main goal is to compare the use of parametric and non-parametric Multi-Shock Indices (MSI) in order to evaluate the cumulative and interaction effects of numerous shocks on household food security in Somalia and to assess these indices' consistency and policy usefulness in identifying vulnerable households. In order to inform targeted and tiered food security treatments, it also examines how multi-shock exposure affects food security outcomes and coping methods across various socio-demographic and economic groups.

The study’s main contribution is the empirical demonstration of non-linear interactions among compound shocks, showing how simultaneous exposures increase vulnerability beyond simple additive effects. Second, it presents an empirical comparison of parametric and non-parametric methods for building the MSI, emphasizing the latter's superior robustness in capturing heterogeneous shock distributions and preventing assumption violations in actual shock data. Lastly, rather than using general descriptive classifications, it offers practical, targeting-relevant vulnerability thresholds and probabilities (integrating observed incidences with predicted exposures) to guide prioritized preemptive action and resource allocation. These developments provide scalable tools for humanitarian and development actors in the face of recurrent, overlapping crises by bridging academic rigor with practical utility.

Conceptual Framework and Derived Hypotheses

A shock is an unexpected event that disrupts normal household, market, or economic activities. These shocks could be negative, such as droughts, wars, or price shocks that threaten livelihoods and worsen poverty, or positive, such as technology or debt relief that gives rise to new opportunities. This study targets negative shocks, defined by four characteristics: unexpected, external, disruptive, and powerful.[2] These shocks can also be categorized as idiosyncratic shocks (which affect only one household) or covariate shocks (which affect whole communities or regions).

A deliberately light conceptual framework of this study (Figure 1) focuses on household vulnerability through the lens of compound shocks and provides non-linear amplification effects exceeding simple additive effects. These overlying shocks rapidly impair a household's ability to cope with and adapt to events and result in food insecurity, loss of livelihood, and fragility.

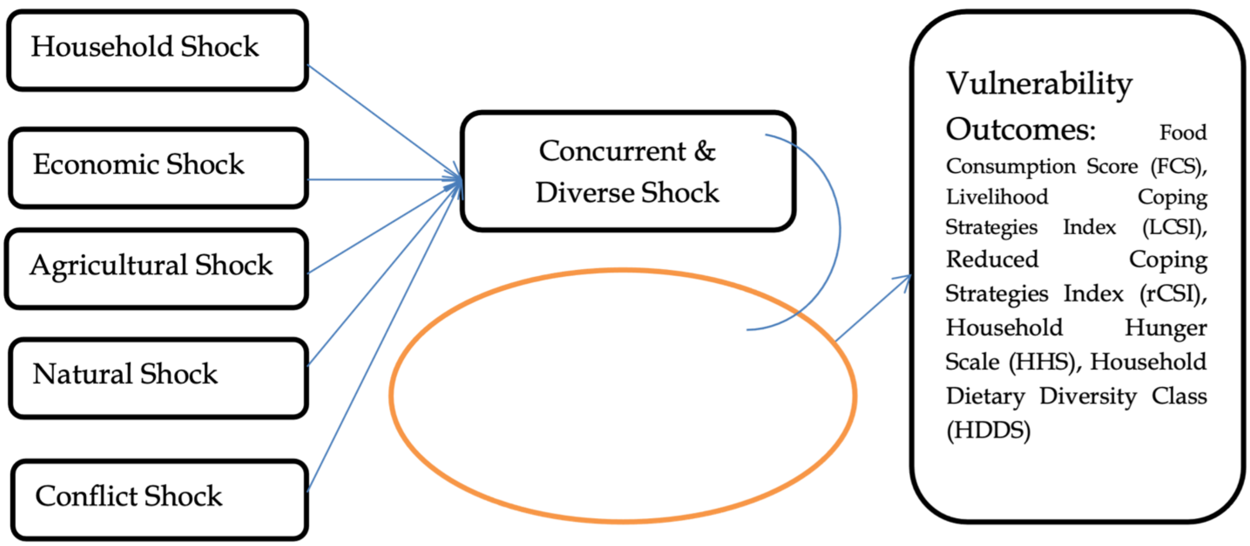

Figure 1: The conceptual framework guiding the analysis.

The multi-shock measure, a composite measure created by the Food and Agriculture Organization's (FAO) Data in Emergencies (DIEM) system, is the subject of the analysis. For a direct empirical evaluation of compound risk exposure, the MSI records shock intensity, variance, and concurrency at the household level. In order to guarantee reliable and accurate vulnerability

[2] Negative shocks possess four defining characteristics that distinguish them from normal economic fluctuations. First, they are unexpected, meaning that households, firms, or governments cannot easily anticipate their occurrence or prepare adequate responses in advance. Second, they are external, originating from outside the control of the affected individuals or communities—such as natural disasters, global price swings, or political conflicts—rather than from internal decision-making. Third, negative shocks are disruptive, interrupting the regular functioning of economic activities, markets, and livelihoods and often forcing households and institutions to adjust behavior, reallocate resources, or deplete assets. Finally, they are powerful, in that their impacts are significant and far-reaching, potentially leading to long-term consequences for income, welfare, and development outcomes.

estimates, both parametric and non-parametric MSI constructors are investigated in light of the diverse and frequently non-normal shock incidence distributions that may arise during crises.

The framework revolves around the non-linear amplification and threshold mechanisms surrounding the MSI. These methods show that the vulnerability outcome might become more noticeable when critical MSI levels are exceeded and that the marginal impact of further shocks increases with shock concurrency. Because shock distributions are heterogeneous and non-normal under crises, this paradigm further emphasizes the empirical distinction between parametric and nonparametric MSI formulations. The observed household vulnerability impacts are then plotted using the MSI, which offers a clear and practical connection between compound risk exposure and welfare implications that are pertinent to policy.

This focused conceptual framing gives rise to the following clear, testable expectations that guide the empirical analysis:

- H1: Households facing multiple and overlapping shocks will have lower levels of food security than those facing fewer or non-overlapping shocks.
- H2: Various methods for cumulating shock exposure (parametric versus non-parametric Multi-Shock Indices) generate differential groups of vulnerable households with alternative implications for targeted intervention in food security programs based on cumulative shock exposure.
- H4: The association between the level of cumulative shock exposure and food security status follows a non-linear pattern, whereby the marginal effect of an increase in the level of shock exposure becomes different at higher levels of cumulative shock exposure.
- H5: The higher the cumulative shock a household experiences, the more that household resorts to stress, crisis, or emergency coping, which affects dietary diversity.

Methodology

Research Design

This study uses a quantitative and cross-sectional approach to analyze the combined impact of compound shocks on the nutritional food security state of Somali households. The study applies data from the DIEM dataset collected from the FAO. This dataset shows the level of shock exposure, the response of households to shocks, and the benefits gained from the shock response. The research design involves accurately measuring and comparing the response of households toward the policy goals concerning the anticipatory action based on the structure of the data contained in the DIEM dataset and the operational goals for the anticipatory action.

The MSI offers an index representing the multiple shocks that households in Somalia have experienced and highlights household exposure to various shocks. This design emphasizes the concurrent, varied, and intense nature of the shocks as a way to measure compound risk, where the interaction between the various shock types compounds the degree of vulnerability that a household experiences, as opposed to considering shocks independently of one another.

The research intentionally employs both the parametric and non-parametric MSI definitions. The non-parametric definition will be applied to the analysis of vulnerability, as the overall distribution pattern of shock indicator data depicts heterogeneity and non-normality. Secondly, the application of the specific MSI definition addresses targeting and the ranking of the household vulnerability.

However, the parametric MSI definition applies as an analysis instrument that does not compete with or substitute other analysis methodologies with regard to the examination of risk related to food security. Based on the standardized scales and linear aggregation applied to the change of the shock intensity definition, the analysis allows scenarios to assist with anticipatory application tasks associated with food security assessments to model the future risk associated with food security.

In addition, the design of this research acknowledges Somalia's socio-ecological diversity in regard of its level of exposure to conflict. In this case, the methodological approach adopted for this research allows for the detection of context-driven patterns of vulnerabilities without camouflaging them through the average results within the nation. Specifically, it connects its empirical results to its practicability through finding non-linear effects of amplification and empirical thresholds of vulnerabilities, hence arriving at evidence for specific resilience actions and prioritization of social safety nets, market stabilization, and anticipatory assistance for those households that receive multiple shocks and suffer negative impacts on household food security.

Key Features of DIEM in Somalia

The FAO DIEM Somalia program is a system for collecting and analyzing data with a view to providing timely, evidence-based analysis of the impact of shocks on food security, livelihoods, and agricultural systems in crisis settings. DIEM in Somalia aims at the nation's complex and recurring issues of conflict, drought, floods, locust plagues, and economic decline, which drive widespread food insecurity and humanitarian needs (FAO, 2024). This study focuses on Rounds 5 and 6 of the DIEM survey because these rounds offer more complete, harmonized, and consistently weighted shock data, which are essential for constructing a robust regression-based MSI. Round 5 (2,479 households) was conducted between December 2022 and January 2023, while Round 6 (2,917 households) was conducted in June–July 2023. Both rounds covered 17 regions of Somalia; Banaadir (Mogadishu) is usually excluded from the household surveys. The key variables include household characteristics, shock exposure, food security outcomes, and coping strategies. Multiple imputations were also used to impute realistic values for those variables with high missingness, conditioning on other observed characteristics from the households. Multiple imputations involved the creation of various imputed data sets, running each separately, and thereafter pooling the results in order to handle the uncertainty introduced by missing data (Little & Rubin, 2019). Patterns of missingness were tested by regions and survey rounds to check that missing values did not differentially affect specific subgroups.

Method of Analysis

The MSI aims at capturing concurrent shocks and overlapping structural vulnerabilities to those shocks that impact households' ability to maintain their resilience in the face of two or more simultaneous shocks. It applies equal weighting among the five shocks, rather than weighting each shock equally; for instance, there have not been studies that show that climate-related shocks cause more harm than conflict-related shocks. While the decisions made regarding the parameters established in developing the MSI are normative, the parameters can be changed in other contexts or for other purposes based on empirical analysis of the data available and operational relevance. In this study, the patterns of the MSI (non-linear amplification, threshold effects, nonparametric method, etc.) have confirmed their robustness based on several sensitivity analyses.

Distinct analytical roles of parametric and non-parametric MSI

The parametric MSI better identifies high levels of vulnerability by focusing on standardized exposure to shocks, which takes relative intensity into account in order to allow interregional/household comparison. This approach is based on extreme cases to pinpoint households that were most exposed to multiple simultaneous shocks. At the same time, the parametric MSI also detects households that belong to the top tail of the shock distribution array by pinpointing non-linear effects, like the diminishing marginal returns principle that comes into play after high levels of exposure to shock that were already extremely high.

The non-parametric MSI estimates the range and diversity of vulnerability across households with an unweighted or ranked approach that acknowledges the number and distribution of shocks independent of parametric assumptions. It can register the broader vulnerability of the general population, including households that face moderate but concentrated shocks. From an analytical perspective, the non-parametric MSI would assess a wider vulnerable community that could register vulnerability and concentrated distributions and could be missed with parametric estimates. It would be very effective for early interventions or community work that could reduce vulnerability among a wider community of households.

Parametric and non-parametric MSIs complement each other in informing the response strategies needed to mitigate household vulnerability. In this regard, the parametric MSI is more sensitive to extreme cumulative shocks and hence efficient in identifying vulnerable households that require intensive humanitarian assistance. Additionally, with its sensitivity to non-linear shocks, this index is more suited for targeting households that require intense humanitarian interventions. On the other hand, the non-parametric MSI is important in identifying overall moderate shocks within the population. Therefore, this index is more suited for preventive programs that aim at building resilience. Through these indices, a tiered strategy can be informed whereby resources are directed toward households identified by the parametric MSI.

Construction of non-parametric MSI

An MSI DIEM survey is created by critically reconsidering how shocks are aggregated and weighted, particularly regarding food security metrics and data integrity. The following six-step process describes its methodology:

a) **Identification and filtering of shocks:** Shocks are coded as binary variables that are equal to 1 if a household faces the shock and 0 in any other situation. The second component is to estimate how important these shocks are; each shock is assigned to food security outcomes using the Food Consumption Score (FCS).

$$FCS_{shock} = E\left[FCS / s_i = 1\right]$$
$$FCS_{nonshock} = E\left[FCS / s_i = 0\right]$$

The methodical approach compares the mean FCS of households that have experienced a specific shock to that of those who haven't; it then estimates the impact of the shock on food security.

$$\Delta_i = FCS_{shock} - FCS_{nonshock}$$

A negative Δi indicates that exposed households are in a worse situation concerning food security than non-shocked households. Therefore, only shocks where Δi<0 are retained for inclusion within the index, i.e., only those shocks whose effect is strictly negative on household welfare are included in the MSI. Filtering the shocks in this way aligns the index with impact-based selection rather than the application of arbitrarily determined thresholds. This is an empirical choice criterion based on the theoretical relation between shocks and welfare effects (Devereux, 2001; Ulimwengu & Marivoet, 2025).

b) **Coping strategy screening:** Coping strategy variables are filtered based on the completeness of the data so that they become valid and reliable. Specifically, a coping strategy is retained only when the proportion of missing responses is less than 10 percent. Statistical validity is achieved in this process, and bias introduced by excessive nonresponse rates is avoided. The proportion of missing values for every variable is calculated as:

$$\text{Missing Share}_j = \frac{\text{Count of Missing Observations in } c_j}{\text{Total Sample Size}} \times 100$$

Using this cut-point, only those coping behaviors that have sufficient response coverage are taken into account while analyzing, thus reducing the risk of bias that could be associated with high rates of nonresponse. This preserves the robustness of the MSI by restricting consideration to only statistically sound and control variables as controls. Variables for which $MissingSharej$<10% are included in the list of "good" coping strategies.

c) **Shock Categorization:** The shocks that persist are categorized into five general compound categories in order to distinguish from several other dimensions of household vulnerability: economic shocks (such as high food and fuel prices), agricultural shocks, natural shocks, conflict shocks, and shocks at the household level. A reasonable OR operator is employed in the compilation of each category, such that a household is coded as having experienced a type of shock if it has a minimum of one shock within a category. For instance, the economic shock category includes shocks such as rising food prices, rising fuel prices, and other similar events. It can be measured as:

$$shock_{economic} = \square(shock_{higherfoodprices} = 1 \; V \; shock_{higherfuelprices} = 1 \; V \ldots)$$

Here, the ∨ symbol indicates the logical OR operator, which will return a value of 1 if at least one of the shocks listed and 0 if none of them are. This ensures that every household's exposure to economic (as well as agricultural, natural, conflict-related, and household-level) shocks is noted exhaustively and without replication.

The Non-parametric Index Construction is built in two stages: unweighted and population-weighted. The unweighted compounded index is obtained by summing across the five compound shock categories. Formally, this is expressed as:

$$CompoundedIndex = shock_{econiomc} + shock_{agriculture} + shock_{natural} + shock_{conflict} + shock_{household}$$

In order to correct for representativeness among the population, a population-weighted index is subsequently constructed. For this case, each shock component is weighted using the corresponding household survey weight, wi, such that:

$$shock^{c}_{popwt} = w_i . shock^{c}$$

Finally, the population-weighted compounded index is derived by summing all weighted components for the five groups:

$$CompoundedIndex^{popwt} = \sum_c shock^{c}_{popwt}$$

This two-stage process ensures that the index captures both the extent of household shocks and their prevalence in the population and provides a better representative and truer measure of vulnerability.

Construction of the parametric MSI / Endogenous Shock Index

The Endogenous Shock Index in the DIEM household survey introduces a parametric approach that marks a substantial advancement over conventional binary. Instead of merely recording whether a household experienced a shock, this method estimates the underlying probability of shock occurrence based on household and contextual characteristics, thereby embedding the index within an econometric framework.

For each retained shock, specify a logistic model:

$$\text{logit } (P(s_i = 1) = \ln \frac{P(s_i = 1)}{1 - P(s_i = 1)} = g(X_i, Z_i)$$

wherein g (·) is typically linear in predictors (you can add interactions or polynomial terms if theory suggests). Include fixed effects (e.g., district) if you want to capture contextual heterogeneity.

After estimating each shock model using Maximum Likelihood Estimation (MLE) or penalized MLE when necessary, the model's performance should be evaluated in terms of both discrimination (Receiver Operating Characteristic (ROC) curve and its corresponding Area Under the Curve (AUC)), calibration (Hosmer–Lemeshow test)) and other methods (calibration plots, the Brier score, and the calibration intercept and slope). Once tests are satisfied, predicted probabilities (shock intensity scores) are computed for every household, and every modeled shock computes P^ (si=1). These P^-values are continuous intensity scores capturing the household's latent propensity to experience that shock. It then aggregates predicted probabilities into groups. For each compound category (economic, agriculture, natural, conflict, household), sum the relevant predicted probabilities:

$$x_{group,i} = \sum_{s \in group} \hat{P}(s_i = 1)$$

This produces a continuous group score per household that reflects both likelihood and multiplicity of exposure. Finally, it constructs the overall parametric compounded index. Sum the group scores to get the household-level compounded index:

$$x_{compounded,i} = x_{economic,i} + x_{agriculture,i} + x_{natural,i} + x_{conflict,i} + x_{household,i}$$

A population-weighted score is computed by multiplying each household's group score by its survey weight and summing or averaging appropriately for population-level summaries:

$$wx_{group,i} = w_i . x_{group,i}$$
$$wx_{compound,i} = \sum_{group} wx_{group,i}$$

For household-level analyses, keep the unweighted xgroup, i , but use wi in downstream regressions or when presenting population estimates.

Once the compounded index is computed, it can be normalized to facilitate interpretation and policy use. Common approaches include rescaling the index to a [0, 1] range using min–max normalization, standardizing it to a z-score with mean 0 and standard deviation 1.

Vulnerability thresholds and robustness analysis

Both parametric and non-parametric MSI specifications are used to adequately capture the magnitude, richness, and concurrency of shocks faced by households. The criteria used to classify a household as "high risk" involves two methods. Based on non-parametric specification, using the 75th percentile cut-off, the top 25 percent of households with the highest scores in terms of MSI are considered to be in a "high risk" category, capable of accommodating and capturing skewed and diverse shock distributions found in household shock data. The mean plus one standard deviation (SD) criteria, based on parametric specification, includes those scores in a household's MSI statistical calculation that are greater than average, setting a standard cutoff at about 15 to 20 percent of a statistical distribution under a normal distribution assumption.

Sensitivity analysis of thresholds

Sensitivity analyses regarding the high-risk categorization for different options of the threshold were performed. For the non-parametric MSI, additional percentiles explored were the 90th percentile, indicating the top 10 percent exceeding the baseline by significantly more, and the 95th percentile, indicating the top 5 percent of values that indicate extreme risk. For the parametric MSI, thresholds were changed according to the baseline. Specifically, these were thresholds set to mean + 0.5 SD (a more inclusive threshold reflecting a moderate level of risk) and thresholds set to mean + 1.5 SD (a more stringent threshold reflecting more extreme levels of risk). The proportional calculations of the number of high-risk households for each threshold level have been carried out using the total sample size (N = 5,394). The findings were set out to identify how sensitive each threshold level classification was to the thresholds.

Ranking stability and rank correlation analysis

A study comparing various MSI specifications and thresholds within rank correlations was carried out in order to have a better understanding of the robustness of the household rankings. The degree of association between household ranks from lowest to greatest risk was measured using rank correlation coefficients (Spearman's Rho,ρ, and Kendall's Tau, τ). The following comparisons were made: (i) evaluating the internal stability of the parametric framework by comparing each parametric MSI at various thresholds (the mean +0.50 SD, the mean +1.00 SD, and the mean +1.50 SD) and (ii) evaluating cross-method consistency between the parametric MSI (baseline mean +1.00 SD) and the non-parametric MSI at the 75th, 90th, and 95th percentiles. The entire dataset was used to compute the correlations, and standard statistical tests at conventional levels were used to assess statistical significance. While the low degree of correlation between parametric and non-parametric rankings reflects the complementary nature of the two indices, a high degree of correlation within the parametric framework for the three thresholds suggests that the rankings are extremely stable.

The MSI-based high-risk designation has obvious operational importance for proactive measures in terms of resource allocation and focused interventions in Somalia's crisis-prone areas, in terms of both policy and operational implications. Even in strongly skewed distributions, the nonparametric MSI can identify the top quartile of vulnerable households, making it particularly well-suited for policy-driven targeting. However, the parametric MSI provides a statistical viewpoint that might reveal early excessive exposure, which could help with early warning monitoring or scenario analysis.

Together, these two methods provide complementary information, with the parametric MSI pointing to vulnerable households with statistically different exposure to shocks and the non-parametric MSI identifying people in broader groups.

Results, Discussion, and Analysis

Descriptive Analysis: Household, Shocks & Hazards, Food Security Indicators

Household structure in Somalia provides useful insight into the social and economic composition of groups and their capacity to withstand shocks. Somali households vary in size, typically reflecting extended family arrangements, and household heads tend to be male. Residence types range from permanent dwellers to returnees, IDPs, and refugees, highlighting the effects of conflict, drought, and migration on residence patterns. Levels of education are predominantly low, with limited access to formal education, particularly in rural settings, while farming activities are prevalent and form a vital source of livelihood. Household head age and marital status structures further shape household composition and decision-making, resource allocation, and shock exposure (Table 1).

Table 1: Socio-demographic characteristics of Somali households

No.	Variables	Categories	Frequency	Percent	Weighted Percent
1.	Household Head Gender	Male	3,058	56.67	56.78
		Female	2,338	43.33	43.22
2.	Household Head Education Level	None or didn't complete primary school	1,546	29.15	29.21
		Completed primary school	635	11.97	10.16
		Completed secondary school	331	6.24	6.69
		Completed a higher education University / college degree	137	2.58	3.31
		Religious or informal education only	2.505	47.24	47.12
		Don't know	148	2.79	2.86
		Refused	1	0.02	0.01
3.	Household Martial Status	Single / never married	279	5.17	5.18
		Married	4,281	79.34	79.01
		Separated	88	1.63	1.60
		Divorced	341	6.32	6.49
		Widowed	405	7.51	7.65
		Don't know	2	0.04	0.03
4.	Household Head age	Under 18	4	0.07	0.05
		18 to 40	3,246	60.19	60.22
		41 to 65	1,825	33.84	34.04
		Over 65	318	5.90	5.68
5.	Household Size Range	0-7	1,134	21.02	21.06
		7-14	3,592	66.57	66.24
		14-21	479	8.88	8.96
		-	191	3.54	3.73
6.	Household residence type	Permanent resident (>2 years in village/town, habitual residence)	4,211	78.04	77.49
		Recent migrant not forcefully displaced	265	4.91	4.89
		Returnee (displaced, returned within two years)	89	1.65	1.47
		Internally displaced person (IDP)	438	8.12	8.54
		Refugee	392	7.26	7.59
		Refused	1	0.02	0.01
7.	Household Agricultural Activity	Crop production	1,937	35.90	37.17
		Livestock production	2,358	43.70	41.83
		Both crop and livestock production	691	12.81	12.73
		Non-agriculture	410	7.60	8.27

Table 2 presents the patterns of shocks and hazards faced by Somalia households and reveals stark vulnerabilities where exposure exceeds 10 percent, underlining threats to livelihood and food security: drought, (31.69 percent) is the most devastating to agrarian systems; food price increases, 24.65 percent) exacerbate malnutrition; other economic shocks (18.55 percent), and animal disease (16.85 percent) contributes to income and nutritional insecurity. Job loss, intra-household issues, pests, and plant diseases (14.68 percent, 13.47 percent, 13.31 percent, and 12.45 percent, respectively) affect more than one in eight households and erode coping mechanisms. Dominated by climate-agronomic and economic stressors, these converging stressors keep poverty cycles going among vulnerable populations, necessitating urgent, resilient interventions like diversified livelihoods, climate-smart agriculture, and safety nets to arrest cascading impacts.

Table 2: Patterns of shocks and hazards

Shock Categories	Types	Response	Frequency
Household Shocks / Idiosyncratic Shocks	Loss of employment or work	No	85.32
		Yes	14.68
	Intra-household	No	86.53
		Yes	13.47
Economic Shocks	Higher food prices	No	75.35
		Yes	24.65
	Higher fuel price	No	93.03
		Yes	6.97
	Movement restriction	No	92.83
		Yes	7.17
	Other economic	No	81.45
		Yes	18.55
Agricultural and Livestock Shocks	Pest outbreak	No	86.69
		Yes	13.31
	Plant disease	No	87.55
		Yes	12.45
	Animal disease	No	83.15
		Yes	16.85
	No pasture	No	95.03
		Yes	4.97
Nature Shocks	Other crops and livestock	No	95.89
		Yes	4.11
	Cold, temperature, hail	No	99.52
		Yes	0.48
	Flood	No	96.87
		Yes	3.13
	Hurricane	No	98.89
		Yes	1.11
	Drought	No	68.31
		Yes	31.69
	Earthquake	No	99.96
		Yes	0.04
	Landslides	No	99.83
		Yes	0.17
	Natural fire	No	99.11

		Yes	0.89
	Other natural hazard	No	98.63
		Yes	1.37
Conflict and Man-Made Hazards	Violence/insecurity/conflict	No	95.63
		Yes	4.37
	Theft of productive assets	No	99.07
		Yes	0.93
	Man-made fire	No	99.74
		Yes	0.26
	Other man-made fire	No	98.11
		Yes	1.89

The overall number of shocks, as shown in Figure 2, is that only 27.2 percent of Somali households reported no exposure to shocks, while almost three-quarters reported exposure to one or more shocks. The majority of the households experienced one (24.7 percent) or two (19.4 percent) shocks, while lower percentages experienced three (13.2 percent) or four (7.7 percent) shocks, which are representative of the cumulative effect of the vulnerabilities. While very few households had an extremely high number of shocks, there were cases of 21 shocks or more recorded, with evidence of extreme exposure among some households. These findings affirm not only the universality of shocks but also the proclivity for such shocks to be numerous, adding to their impact on livelihoods, food security, and general household resilience. Furthermore, the overlap of the shocks—for example, drought with higher food prices or disease affecting livestock—shows the need for complementarity in resilience-building interventions against both environmental and economic risks.

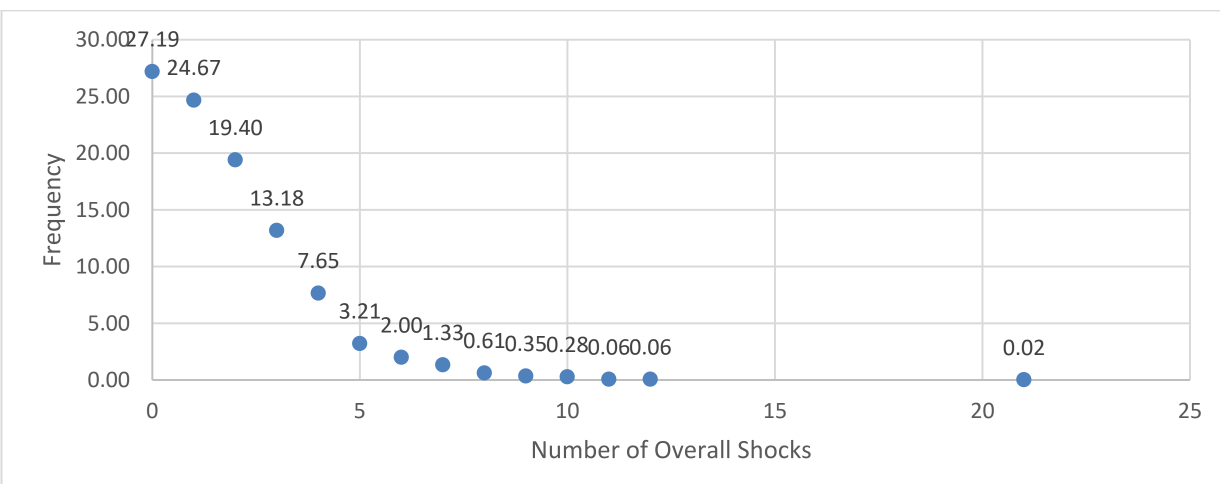

Figure 2: Distribution of households by number of overall shocks

Table 3 shows that 35.67 percent of the population experiences little to slight hunger (IPC Phases 1–2), reflecting that a minority of households enjoy relatively stable access to food. The majority of households (54.60 percent) fell into Phase 3 (moderate hunger), in which households experience food shortages or insufficient consumption on a recurring basis. A smaller share (9.73 percent) fell into Phases 4–5, characterized by severe levels of food deprivation and going without food for days in a row. Compared to FIES[3], HHS refers only to the frequency of occurrences of actual hunger; this is why the rate of severe cases is lower than the severe category of FIES. However, both indicators confirm a heavy burden: Nearly 88 percent of respondents experience moderate-to-severe experiences on FIES, and over 64 percent experience moderate-to-severe hunger on HHS. The findings indicate a dire need for intervention targeted at both access to sufficient food and household coping strategies, especially since more than half of the households reported extreme food insecurity.

Table 3: FIES Scores based on experiences of food insecurity

Food Insecurity Experience Scale (FIES)		
FIES raw score	Percent	Remark
0	3.22	Fully food secure
1–3	8.78	Mild food insecurity
4–6	34	Moderate food insecurity
7–8	54	Severe food insecurity
Household Hunger Scale (HHS)		
HHS raw score	Percent	Remark
0 (Phase 1)	20.03	No hunger
1 (Phase 2)	15.64	Slight hunger
2–3 (Phase 3)	54.60	Moderate hunger
4 (Phase 4)	5.89	Severe hunger
5–6 (Phase 5)	3.84	Severe hunger

On measures based on dietary diversity and food frequency, the results in Table 4 indicate that dietary diversity is limited for most of the households. The Household Dietary Diversity Score (HDDS) indicates that 32.1 percent of the households fall under a low category of dietary diversity, consuming 0-2 food groups and dominated by staple foods with very limited nutrient-dense products. Another 37.2 percent fall into the medium category, with 3-4 food groups and moderate dietary diversity, thus still being vulnerable to nutrient deficiencies. Only 30.7 percent of households fall into a category of high dietary diversity, with 5-12 food groups, reflecting improved access to food and better diet quality. Similarly, the FCS result shows that 24.5 percent of households fall under the poor consumption group characterized by highly poor variety, while 26.6 percent of households fall under the borderline category with marginally higher variety, but still

[3] Both food insecurity indicators reflect different levels, ranging from a state of being worried to one of extreme hunger. FIES captures all levels of food insecurity, from mild worry to extreme hunger, whereas HHS is interested in the levels of acute hunger experiences. Programmatically, HHS is best for reaching emergency relief and rapid measurement of severe hunger, while FIES is appropriate for longer-term monitoring and cross-country comparability, including SDG reporting.

staple-based. Most households (48.9 percent) have only satisfactory levels of food consumption reflective of good diet diversity and relative food security. Taken together, these figures suggest that more than half of Somali households, or close to 70 percent, consume diets that are nutritionally poor in terms of either diversity or frequency.

Table 4: HDDS Scores based on dietary diversity and food frequency

Household Dietary Diversity Score (HDDS)			
HDDS Category	Score Range	Percent of Households	Remark
Low Dietary Diversity	0–2	32.12	Households consume very few food groups, mainly staples, indicating poor diet quality and a high risk of nutrient deficiencies.
Medium Dietary Diversity	3–4	37.23	Households consume a variety but still have limited access to nutrient-rich foods such as fruits, vegetables, and proteins.
High Dietary Diversity	5–12	30.65	Households consume a wide range of food groups, reflecting better food access, quality diets, and higher food security.
Food Consumption Score (FCS)			
FCS Category	Score Range	Percent of Households	Remark
Poor	0–21	24.52%	Households have very limited food consumption, mainly staples and vegetables, indicating inadequate food access and poor diet quality.
Borderline	21–35	26.58%	Households consume slightly more variety but still rely heavily on staples; the risk of food insecurity remains high.
Acceptable	>35	48.91%	Households have adequate food consumption and diversity, suggesting relatively good food access and security.

Regarding household coping strategies (Figure 3), the LCSI is extremely concerning for household exposure, pointing to a severe, widespread humanitarian crisis with unsustainable coping being the standard. With 97.63 percent of Somali households analyzed employing at least one strategy and over three-quarters (74.43 percent) in the Emergency (IPC Phase 4) level of food insecurity, the data suggests severe food insecurity and livelihood deterioration. This level of distress is extremely high compared to international levels; for instance, WFP (2024) reports depicting Emergency levels of 20-40 percent in prolonged crises like those seen in Yemen or South Sudan.

Just 2.37 percent of households are classified as No-Coping (food secure), suggesting erratic resilience that may be supported by a variety of sources of income or strong safety nets. Only 4.89 percent of analyzed households turn to Stress-level coping, using reversible strategies like drawing on savings or informal lending, which signal underlying financial stress but are reversible; this tight buffer zone may mean that minor interventions (e.g., microcredit access) could stabilize these families, but those interventions' low prevalence may drive households to adopt more extreme approaches. Crisis-level coping mechanisms, taken by 18.31 percent of the households, include productivity-destroying behaviors such as selling productive assets or cutting back on immature crops, an escalation hotspot where repeated shocks (e.g., drought or inflation) threaten to drive these households into extreme distress. Most importantly, 74.43 percent of the households are relying on Emergency-level coping mechanisms such as the sale of household assets, the sale of the last female livestock, or investigation of total household migration—actions that exacerbate poverty and heighten malnutrition, child labor, and social unrest threats. This record Emergency level, which is far higher than WFP's threshold danger level of 30 percent, shows a breakdown of resilience, where desperation overtakes sustainable planning and trends towards IPC Phase 4 (Emergency) or higher. Policy interventions must accord highest priority to emergency interventions like unconditional cash transfers and asset replenishment to the households in Emergency-level food insecurity, productivity support (e.g., input subsidies) to households in Crisis, to prevent further deterioration, and resilience-building interventions among the 7.26 percent in lower categories to gain stability.

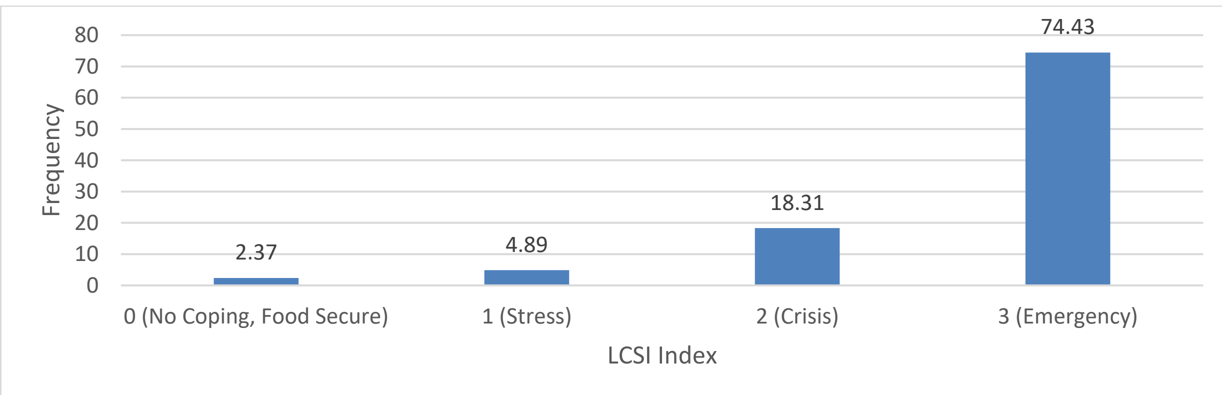

Figure 3: Distribution of households by the LCSI index (%)

Note that the WFP's Consolidated Approach for Reporting Indicators of Food Security (CARI) and the DEIM (Data Entry, Integration, and Monitoring) guidance show that livelihood coping is always grouped into these four standard categories: 0= None (no livelihood stress reported), 1 = Stress (strategies that indicate reduced ability to cope without yet undermining future livelihood potential, e.g., using savings, borrowing from relatives), 2= Crisis (strategies that damage productive capacity, e.g., selling productive assets, reducing input expenditures), and 3= Emergency (most severe, undermining future survival and wellbeing, e.g., selling the last female animal, withdrawing children permanently from school, or migration)

Figure 4 presents the Reduced Coping Strategy Index (RCSI). The RCSI is a food security construct built to capture the variety and depth of food-related coping strategies taken by households in the event of inadequate access to food. Unlike the LCSI, which focuses on asset- and livelihood-based coping, the RCSI captures activities directly associated with food consumption adjustments, such as reducing the frequency of meals, eating less preferred foods, skipping meals, or adjusting consumption toward children but away from adults. Only 4.39 percent of analyzed households classify as coping-class households, i.e., those who rarely practice food-related coping behavior. A majority percentage (31.55 percent) of the households are medium coping (stressed), in that they often change food consumption habits but in reversible terms. Worryingly, the majority — 64.05 percent of households — fall under the high coping class (crises), which reflects widespread and severe use of food coping mechanisms. This indicates a preponderance of acute distress, where hypertrophic patterns of coping undermine health and livelihoods, and where intervention is indispensable. The 95.6 percent of households within medium or high coping classes indicates generalized food insecurity likely as a result of systemic shocks.

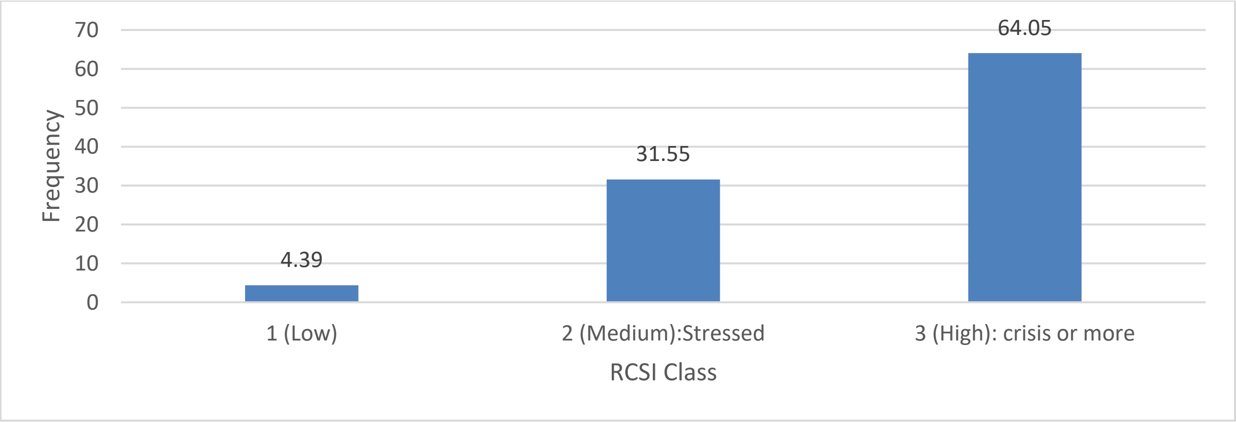

Figure 4: Distribution of households by RCSI class (%)

The convergence of high LCSI and high RCSI prevalence implies that households are not only adopting riskier livelihood strategies but are also experiencing direct effects on food consumption and thus are more exposed to shocks and less resilient. Such combined findings suggest that a high proportion of households experience severe food stress with limited ability for resistance to further shocks, highlighting the need for immediate food assistance as well as livelihood and resilience-building interventions.

Analysis of the Constructed Non-parametric and Multi-Shock Index (MSI

A thorough comparison of parametric and non-parametric MSIs derived from FAO's DIEM household-level data is presented in Table 5. The summary statistics are essential for identifying high-risk households and implementing supportive measures since they offer information about the distributional properties of both indices as well as their methodological differences.

The total shock exposure for the households is fairly low to moderate, as seen by the average cumulative shock exposure of 13.3 percent for the non-parametric MSI and 14.6 percent for the parametric MSI, out of the maximum possible shock exposure. This indicates that the households analyzed in this study had relatively little overall shock exposure. The ability to withstand shocks, coping mechanisms, or the rarity of acute shock combinations could all contribute to the overall low exposure. "Maximum possible" makes the highly improbable assumption that the household has experienced the greatest shock exposure during the research period. Instead, just a few shock combinations are experienced by the households.

The low to medium shock exposure (13.3-14.6 percent of maximum possible) is a result of important factors commonly found in studies of vulnerability. The presence of shocks is varied, such that it is extremely unlikely for a household to be faced with every type of shock to the fullest possible extent. All shocks do not need to affect every household to the same degree based on geography, employment status, or socio-economic factors. The majority of shocks are either rare or of low severity, with serious exposures being exceptional for most. The data of measurement is typically over a shorter period of time, leading to lower accumulations. Effective household buffers such as savings, diversification, insurance, or social protection can reduce the severity of exposure. In this case, there is a low shock exposure such that it is clear a substantial number of households are only rarely faced with overwhelming multi-shock situations.

The analysis shows standard deviations of 0.130 for the non-parametric MSI and 0.085 for the parametric MSI, with higher skewness values, -1.211 versus 0.876-and somewhat lower kurtosis-4.924 versus 5.24-in the non-parametric measure. This suggests that while most households have low to moderate levels of cumulative shock exposure, there is considerable variation within the sample, with a small number experiencing much more substantial shocks (thus, positively skewed distributions with fat tails relative to a normal distribution). Accordingly, the greater dispersion, skewness, and kurtosis for the non-parametric MSI are because this preserves raw heterogeneity and extreme values with no assumptions imposed on it, completely capturing the outliers affected by severe or multiple shocks. Conversely, the parametric MSI decreases variance, skewness, and heaviness of the tail due to standardization and smoothing. In contrast to the non-parametric approach, it yields a more uniform and normalized distribution that allows conventional statistical analysis.

Percentile analysis of MSI shows that the 25th percentile for non-parametric MSI is 0 and that of parametric MSI is 0.088; the 50th percentiles corresponding to the median are 0.118 and 0.134; and the 75th percentiles are 0.204 for non-parametric and 0.195 for parametric. This means that at least 25 percent of the households experience no or very low exposure to shock, half have low-to-moderate levels, and the top quartile faces notably higher but still moderate cumulative shocks overall. On the other hand, surprisingly similar values of the 75th percentile show that both indices identify comparable groups of high-exposure households. These patterns arise because the non-parametric MSI preserves raw relative exposure, with many zeros at the low end. This allows the top quartile to capture the highest actual shock burdens among households. On the other hand, the parametric MSI applies normalization and smoothing, shifting the low-end values upward but aligning at the upper tail closely to flag statistically extreme cases. These make both approaches effective in targeting the most vulnerable households for interventions, albeit through slightly different characterizations of the risk.

Table 5: Statistical summary for non-parametric and parametric MSI

Statistic	Non-Parametric MSI	Parametric MSI
Mean	0.133	0.1460
Standard Deviation	0.130	0.0852
Variance	0.016	0.0072
Skewness	1.211	0.876
Kurtosis	4.924	5.24
Minimum	0	0
Maximum	1	1
25th Percentile	0	0.088
Median (50th percentile)	0.118	0.134
75th Percentile	0.204	0.195

Comparative descriptive statistics for the two MSI models show different yet complementary patterns of household shock vulnerability in the Somalia context, in that the parametric MSI follows a pattern of lower variance, skewness, and greater continuity in the data than the non-parametric MSI. That is, the parametric MSI model is optimal for monitoring the steady increase in mean levels of risk and therefore is necessarily ideal for early warning systems, anticipation plans, and scenario modeling analyses, compared to the non-parametric MSI, which optimally detects those household units in the upper tail of the data that receive extreme shocks. Such differences lie in the fact that while parametric is using standardization and smoothing to distill and focus more on change in aggregate risk sensitivity, the non-parametric method is using raw risk distribution and extreme values to focus more on the most at-risk households. Therefore, policy ought to consider using two different indices simultaneously—using the non-parametric MSI to deliver emergency assistance and safety nets to the most at-risk groups and the parametric MSI to plan preventive action.

High-risk Household Identification

From the analysis (Table 6), the non-parametric MSI shows 1,350 households to be high-risk, accounting for 25.03 percent of the sample, using the threshold of the 75th percentile, at the value of 0.2048549, while the parametric MSI shows 1,142 households to be high-risk, accounting for 15.62 percent, using the threshold of Mean + 1 SD, at the value of 0.231. This is to say that a quarter of the total number of households, according to relative exposure, are high-risk through the non-parametric method, while one-sixth, according to statistical variation, are high-risk through the parametric method. This finding reveals a complementary analysis depending on the discourse and the applicability of the policy at hand, in which the non-parametric, through the use of percentile, tends to cover the top quartile essentially, irrespective of the distribution properties, while the parametric, through the use of mean plus one standard deviation, tends to cover fewer cases that are, however, more distant from the norm. Thus, it is applicable to policy selection for the non-parametric assessment to cover the whole safety net and the parametric to target the most outlier regions, accordingly.

Table 6: Proportion of high-risk households

High-Risk Definition	Threshold Value	Number of Households Above Threshold	Percentage (%)
75th Percentile, under non-parametric MSI	**.2048549**	**1,350**	**25.03**
✓ Sensitivity analysis: test alternative percentiles, 90th,	0.2926176	562	10.42
✓ Sensitivity analysis: test alternative percentiles, 95th	0.4097098	270	5.01
Mean + 1 SD, under Parametric MSI	**0.231**	**1,142**	**15.62**
✓ Sensitivity analysis: test mean + 0.5 SD	0.188	1,967	26.9
✓ Sensitivity analysis: test mean + 1.5 SD.	0.269	632	8.64

Sensitivity analysis

Sensitivity analysis assessing the stability of high-risk household classification indicates that varying thresholds in the non-parametric MSI alter the number of identified high-risk households from 1,350 (25.03 percent) at the baseline 75th percentile (threshold 0.205), to 562 (10.42 percent) at the 90th percentile (0.293), and to 270 (5.01 percent) at the 95th percentile (0.410). For the parametric MSI, thresholds range from 1,967 households (26.9 percent) at mean + 0.5 standard deviations (0.188), to 1,142 (15.62 percent) at baseline mean + 1 standard deviation (0.231), and to 632 (8.64 percent) at mean + 1.5 standard deviations (0.269). This indicates that the proportion of households categorized as high-risk varies in a predictable and monotonically increasing manner with the level of threshold stringency across both indices, thereby confirming that the classifications are robust and not sensitive to reasonable threshold variations. The parametric approach uses standard deviation multiples around the mean to reflect its more normalized distribution, while the non-parametric approach uses percentile thresholds appropriate to its heavy right-skewness and zero-inflation, systematically capturing increasingly extreme upper-tail cases. The predictable responses to adjustments show that high-risk designations reflect the true underlying shock exposure distribution rather than methodological artifacts, thereby increasing confidence in the MSI framework's reliability for vulnerability assessment and targeted interventions.

Ranking stability and rank correlations

Spearman's rank correlation coefficient (ρ) and Kendall's rank measure (τ) were used to compare household rankings for different MSI values and specifications for the entire sample. The degree of monotonic agreement for rankings is measured by these non-parametric tests; values near 1 indicate very high levels of agreement. It makes sense that all threshold levels had perfect stability in rankings within the parametric MSI. As would be expected given the linear transformation of the z-score procedure, the test of the base value mean + 1 SD versus both mean + 0.5 SD and mean + 1.5 SD produced $\rho = 1.000$ and τ undefined ($p = 0$).

Poor correlations for $\rho \approx 0.0244$ and $\tau \approx 0.0169$ were found in comparative analyses of the parametric MSI based on mean +1SD and the non-parametric MSI at the 75th, 90th, and 95th percentiles. Both are roughly equal top ≈ 0.07, which are not significant at the standard level of significance $\alpha = 0.05$. The significant difference between the high-risk households found by the two approaches, particularly in the tails, was revealed by the low correlation coefficient.

This low level of concordance among the results of the different methods is owing to a set of inherent discrepancies among them. In the parametric MSI, the emphasis is on the absolute values of oscillation around the mean value in the population, owing to symmetry, whereas in the non-parametric MSI, the stress is more on the percentile values. These results validate not only the internal robustness of the parametric ranking test irrespective of the threshold level used but also the complementarity that exists among them.

In summary, the rank correlation analysis delivers two strong findings. First, it confirms internal stability of the perfect parametric MSI: With respect to the family order values, the Spearman correlation coefficient is identical for the different multiples of the standard deviation parameters, mean + 0.5 SD, mean + 1 SD, and mean + 1.5 SD. Spearman correlation coefficient of 1.000, p-value of 0.000. Second, it shows very limited agreement between the two methods regarding the values of MSI. Cross-method correlations are close to zero ($\rho\_Spearman \approx 0.024$, $\tau\_Kendall \approx$

0.017, p ≈ 0.07) and are statistically insignificant at the conventional levels. However, the two methods appear to identify considerably different groups of high-risk households.

Table 7: Ranking stability and rank correlations

Comparison	Spearman's ρ	Kendall's τ	P-value	Interpretation
Parametric Mean + SD vs. Mean + 0.5 SD	1	–	0	Perfect stability — ranking unchanged across parametric thresholds.
Parametric Mean + SD vs. Mean + 1.5 SD	1	–	0	Perfect stability — ranking unchanged across parametric thresholds.
Parametric (Mean + SD) vs. Non-parametric MSI (75th percentile)	0.0244	0.0169	0.0733 (Spearman) / 0.0708 (Kendall)	Almost no correlation — rankings differ across indices; not statistically significant.
Parametric (Mean + SD) vs. Non-parametric MSI (90th percentile)	0.0244	0.0169	0.0733 / 0.0708	Same as above; confirms low consistency in top-risk households.
Parametric (Mean + SD) vs. Non-parametric MSI (95th percentile)	0.0244	0.0169	0.0733 / 0.0708	Same as above; extreme tail households differ between indices.

Distribution of high-risk households across regions and household characteristics

The MSI was used to identify high-risk households, which were then examined from two complementary analytical viewpoints in order to thoroughly investigate the spatial and socio-demographic patterning of vulnerability: composition perspective and incidence perspective.

The composition perspective quantifies the distribution of high-risk households across administrative regions and key socio-demographic characteristics: gender of household head, education level, marital status, age group, household size, and engagement in agricultural/livestock activities. It addresses, among all high-risk households, which regions and population subgroups contain the the largest absolute shares of high-risk households. For resource allocation, geographic concentrations and dominant demographic profiles within the high-risk caseload are given directly by this approach.

The incidence perspective calculates the share of high-risk households across regions and subgroups, i.e., high-risk households divided by the total number of surveyed households in that category. This allows us to answer such questions as: Given a household is located in some region or given some characteristics, what is the probability of that household being high risk? It pinpoints areas and groups with exceptionally high levels of vulnerability, even when absolute numbers are small, thus outlining relative hotspots of risk.

Both these approaches to—composition as a measure of absolute burden as well as incidence as a measure of relative prevalence—offer a well-rounded framework that is policy-relevant. Composition informs the scaling-up of response as a function of caseload size to focus on vulnerability risk groups in multi-shock environments like Somalia.

A) Composition of high-risk households by region

There is regional heterogeneity in the composition of high-risk households (Table 8) with implications for sub-national targeting in the Somali setting of multiple shocks.

Using the non-parametric MSI with a 75th percentile cutoff, 1,350 high-risk households are represented in all regions, with the highest percentages found in Lower Shabelle (10.9 percent), Woqooyi Galbeed (11.6 percent), Lower Juba (10.6 percent), Mudug (9.2 percent), and Middle Shabelle (9.8 percent) regions, with more than half of the total high risk in the country. In contrast, the parametric MSI-mean + 1 SD threshold gives a stricter subset of households, and 1,142 high-risk households are more spatially concentrated, whereby Lower Shabelle, Mudug, Woqooyi Galbeed, and Bay comprise nearly 68 percent of cases, with 20.8, 16.4, 16.9, and 14.0 percent, respectively. In contrast, a number of regions have a near-zero or zero number of high-risk households under this criterion: Awdal, Bakool, Hiraan, and Sanaag.

This divergence is substantive. The non-parametric specification highlights regions with widespread elevated exposure suitable for broad-based humanitarian targeting and equity-focused allocation, while the parametric specification pinpoints hotspots of severe outlier-driven risk critical for anticipatory action and early-warning prioritization. Complementary regional patterns affirm the added value of a dual-MSI approach in distinguishing absolute caseload burden from intensity-based hotspots with a view to increasing precision and effectiveness in geographically differentiated interventions.

Table 8: Regional distribution of high-risk households

Province name	Non-parametric MSI using 75th Percentile			Parametric MSI using Mean + 1 SD		
	Freq.	Percent	Cum.	Freq.	Percent	Cum.
Awdal	57	4.22	4.22	5	0.44	0.44
Bakool	13	0.96	5.19			
Bari	**110**	**8.15**	**13.33**	**104**	**9.11**	**9.54**
Bay	**115**	**8.52**	**21.85**	**160**	**14.01**	**23.56**
Galgaduud	56	4.15	26	7	0.61	24.17
Gedo	61	4.52	30.52	13	1.14	25.31
Hiraan	16	1.19	31.7			
Lower Juba	**143**	**10.59**	**42.3**	94	8.23	33.54
Lower Shabelle	**147**	**10.89**	**53.19**	**237**	**20.75**	**54.29**
Middle Juba	23	1.7	54.89	37	3.24	57.53
Middle Shabelle	**132**	**9.78**	**64.67**	73	6.39	63.92
Mudug	**124**	**9.19**	**73.85**	**187**	**16.37**	**80.3**
Nugaal	32	2.37	76.22	9	0.79	81.09
Sanaag	6	0.44	76.67			

Sool	61	4.52	81.19	1	0.09	81.17
Togdheer	98	7.26	88.44	22	1.93	83.1
Woqooyi Galbeed	**156**	**11.56**	**100**	**193**	**16.9**	**100**
Total	**1350**	100.01		**1,142**	100	

B) Incidence of High Risk within Regions

Complementing the composition analysis, the incidence of high-risk status shows the share of households surveyed that fall into a high-risk category in each ADM1 administrative region, which indicates the local intensity of vulnerability.

Under the non-parametric MSI, incidence varies widely, ranging from as low as 2.23 percent (Sanaag) to a high of 44.32 percent (Woqooyi Galbeed), with elevated rates above 35 percent: Lower Juba (44.27 percent), Woqooyi Galbeed (44.32 percent), Lower Shabelle (39.73 percent), Middle Shabelle (39.64 percent), Mudug (38.04 percent), and Bari (35.03 percent). These are regions with high or marked relative vulnerability of their populations. The parametric MSI shows greater interregional variation and generally lower average incidence, ranging between 0 percent for several regions that include Bakool, Hiraan, and Sanaag, and 50.43 percent for Lower Shabelle. The highest rates occur in Lower Shabelle (50.43 percent), Mudug (44.84 percent), Woqooyi-Galbeed (33.74 percent), Bay (31.68 percent), and Bari (28.97 percent), indicating concentrated extreme shock exposure. The areas with a high level of incidence across the models—the Lower Shabelle, Mudug, Woqooyi Galbeed, and Bay regions—are high-priority areas where intensive intervention is required.

Table 9: Incidence of high risk within regions

Province name	Non-parametric MSI		Parametric MSI	
	High_risk_75_IM		high_risk_meanSD	
	0	1	0	1
Awdal	82.35	17.65	0.94	100
Bakool	96.07	3.93	100	0
Bari	64.97	**35.03**	71.03	**28.97**
Bay	66.67	**33.33**	68.32	**31.68**
Galgaduud	83.82	16.18	98.48	1.52
Gedo	82.57	17.43	97.05	2.95
Hiraan	95.06	4.94	100	0
Lower Juba	55.73	**44.27**	76.08	**23.92**
Lower Shabelle	60.27	**39.73**	49.57	**50.43**
Middle Juba	87.08	12.92	83.41	16.59
Middle Shabelle	60.36	**39.64**	84.23	15.77
Mudug	61.96	**38.04**	55.16	**44.84**
Nugaal	89.33	10.67	97.19	2.81
Sanaag	97.77	2.23	100	0

Sool	77.74	22.26	99.73	0.27
Togdheer	70.83	**29.17**	95.78	4.22
Woqooyi Galbeed	55.68	**44.32**	66.26	**33.74**

C) Incidence of high risk across population groups

The highest high-risk proportions are consistently found among refugees (parametric MSI: 35.2 percent; non-parametric: 32.4 percent), returnees (31.0 percent; 30.7 percent), IDPs (27.9 percent; 25.1 percent), recent non-forced migrants (27.9 percent; 22.3 percent), and households producing both crops and livestock (24.1 percent; 29.1 percent), whereas fixed permanent residents (23.4 percent; 24.4 percent), and those with completed primary education (8.1 percent; 16.7 percent). High-risk incidence is significantly lower in female-headed households (13.4 percent; 23.8 percent) than in male-headed households (17.5 percent; 26.0 percent); risk is higher in younger household heads (18–40 years: 17.0 percent; 26.4 percent) and larger households (14–21 members: 16.1 percent; 26.7 percent); and the highest education-related risk is found in groups with only religious or informal education (25.0 percent; 31.5 percent).

While female headship and some livelihoods provide relative protection, these patterns show that displacement status and mixed agro-pastoral livelihoods are the strongest drivers of vulnerability. Displaced populations, mixed farmers, and younger male-headed households are given priority for targeted resilience and safety-net interventions. These factors are followed by male headship, youth, larger family sizes, and limited formal education. The disparities result from structural exposures in the context of Somalia's crisis. Forced displacement significantly disrupts networks, assets, and service access; combined crop-livestock systems face compounded climatic risks (droughts affect pastures, floods ruin crops); demographic pressures increase resource strain in larger/younger households; informal education restricts economic diversification; and households headed by women may benefit from targeted humanitarian aid or adaptive strategies. Consistent directional patterns across both MSI specifications reinforce the robustness of these vulnerability drivers.

Table 10: Incidence of high risk across population groups

		Parametric MSI		Non-parametric MSI	
Socio-demographic Group	Category / Level	% Low-Risk (0)	% High-Risk (1)	% Low-Risk (0)	% High-Risk (1)
Household Head Gender	Male	82.48	17.52	73.99	26.01
	Female	86.63	13.37	76.25	23.75
	None or did not complete primary school			81.76	18.24
	Completed primary school	91.87	8.13	83.31	16.69
	Completed secondary school	85.75	14.25	77.04	22.96
	Completed higher education University / College degree	82.78	17.22	80.29	19.71
	Religious or informal education only	75.05	24.95	68.48	31.52
	Single / never married	87.39	12.61	79.93	20.07

Household Head Marital Status	Married	84.01	15.99	74.94	25.06
	Separated	92.23	7.77	82.95	17.05
	Divorced	81.58	18.42	72.14	27.86
	Widowed	87.24	12.76	72.59	27.41
Household Head Age	Under 18	100	0	75	25
	18 to 40	83.02	16.98	73.56	26.44
	41 to 65	86.01	13.99	76.81	23.19
	Over 65	87.32	12.68	78.62	21.38
	0–7 members	84.71	15.29	78.02	21.98
	7–14 members	84.58	15.42	74.38	25.62
	14–21 members	83.91	16.09	73.28	26.72
Household Agricultural Activity	crop production	83.54	16.46	76.34	23.66
	livestock production	87.37	12.63	75.22	24.78
	both crop and livestock production	75.91	24.09	70.91	29.09
	Non-agriculture	84.55	15.45	73.9	26.1
Household residence type	Permanent resident (>2 years in village/town, habitual residence)	76.63	23.37	75.61	24.39
	Recent migrant not forcefully displaced	72.09	27.91	77.74	22.26
	Returnee (displaced, returned within 2 years)	69.06	30.94	69.32	30.68
	Internally displaced person (IDP)	72.14	27.86	74.89	25.11
	Refugee	64.83	35.17	67.6	32.4

Associations Between Multi-Shock Exposure and Food Security Outcomes

It is crucial to describe the general goal of the MSI and the levels of inference being applied in relation to the MSI before the results are presented. The MSI is a diagnostic tool that offers a cumulative measure of the number of shocks to households over time. Ranking households according to their degree of relative vulnerability is the MSI's primary goal. As a result, in both humanitarian and social protection scenarios, the MSI can be utilized to aid with risk profiling and to offer an early warning for the design of target support. It is crucial to emphasize that this analysis shows a correlation rather than a cause.

The validity of high-risk classifications from both MSI specifications is confirmed by robustness analysis using ordered logit and multinomial logistic regression models, which are fully adjusted for household demographics (head's gender, education, marital status, size), livelihood and residence characteristics (agricultural activity, residence type), and administrative-level geographic fixed effects. The results presented as relative risk ratios (RRRs) and average marginal effects (AMEs) in Table 11 show that households in the high-risk categories face significantly elevated risks across multiple vulnerability dimensions, supporting the dependability and policy relevance of both MSI approaches for identifying and targeting the most shock-affected households. These controls were included to isolate the independent effect of cumulative shock exposure by removing confounding influences from demographic, economic, spatial, and residential factors.

Keep in mind that for high-risk versus low-risk households, the Relative Risk Ratios (RRR) show the relative likelihood of a household falling into a particular outcome category relative to the base group; an RRR >1 denotes higher risk, whereas <1 suggests lower risk. When all other factors are held constant, Average Marginal Effects (AMEs) in percentage points indicate the average change in the projected probability of each outcome category associated with being high-risk; positive values indicate increased probability, and negative values indicate decreased probability.

Livelihood stress and coping responses (LCSI and RCSI)

Livelihood Coping Strategy Index (LCSI)

The LCSI's response to households' high-risk exposures carries significant policy implications since it evaluates longer-term (beyond 30 days) livelihood-protecting or depleting coping mechanisms.

Across coping severity levels, the non-parametric MSI threshold shows a distinct and monotonic gradient. MSI high-risk households are more likely to utilize more erosive methods than households reporting no coping, which results in a fourfold increase in the probability of emergency coping (RRR = 4.18, $p < 0.001$). For example, compared to households that are not considered high-risk, high-risk households show a clear escalation in livelihood coping behaviors: they are 3.39 times more likely to adopt stress coping strategies, 3.93 times more likely to engage in crisis coping, and 4.18 times more likely to use emergency coping. This pattern shows that households classified as high-risk gradually turn to more extreme and potentially dangerous coping strategies, indicating a substantial correlation between risk status and rising livelihood vulnerability. A significant behavioral change is confirmed by marginal effects, which show a 3.8 percentage point rise in emergency coping and a comparable 3.1 percentage point decrease in no coping. Strong construct validity is demonstrated by this pattern: Households with acute livelihood difficulties are accurately identified by MSI high-risk status.

The parametric classification, on the other hand, exhibits less robust and coherent discrimination. The gradient is steeper (RRRs < 3), and marginal effects are smaller and frequently statistically insignificant, even though relative risks are higher for crisis and emergency coping. This indicates attenuation as a result of the higher cutoff, which underrepresents earlier stress responses and includes fewer families.

Reduced Coping Strategy Index (RCSI)

Short-term (last seven days) consumption-based coping mechanisms are measured by the RCSI. Results for RCSI are consistent. MSI high-risk households had an 81 percent higher chance of falling into the high (crisis or worse) RCSI group under the non-parametric criterion, with a 4.5 percentage point increase in probability. The view that the non-parametric MSI threshold accurately captures increasing consumption stress is supported by the substantial drop in the likelihood of staying in the low coping category. In contrast, the parametric technique produces lower and statistically insignificant AMEs, suggesting that it has less ability to identify households that are shifting to crisis-level coping.

Food Consumption Score (FCS)

The results of the Food Consumption Score (FCS) show even more striking differences between the two categories. According to the non-parametric MSI definition, the chance of acceptable consumption is drastically reduced by 12.8 percentage points, and high-risk households are over ten times more likely to have poor food consumption. The threshold's sensitivity to significant consumption shortfalls is highlighted by this statistically significant displacement away from acceptable diets. However, similar effects are not detected by the parametric threshold. Marginal effects are negligible and insignificant, and relative risks are almost equal. This implies that households that already face significant dietary compromise but are not severe enough to surpass the mean + SD criterion are missed by the parametric cutoff.

Hunger Severity (HHS)

Additional proof of the non-parametric MSI classification's greater discriminatory ability comes from the Household Hunger Scale (HHS). With a significant 8.7 percentage point decrease in the prevalence of no hunger and a 6.8 percentage point increase in the prevalence of severe hunger, high-risk households exhibit a nearly twofold increase in the risk of severe hunger and a doubling of the risk of moderate hunger. These findings show that households entering physiologically relevant deprivation are successfully identified by the non-parametric threshold. The parametric MSI definition performs poorly for moderate hunger transitions and exhibits weaker overall redistribution over the hunger spectrum, even if it does capture severe hunger (AME = +6.1 points). According to this pattern, households that are already at the most extreme end of deprivation are more likely to be flagged by the parametric method than those that are degrading into starvation.

Dietary Quality and Diversity (HDDS)

The results of dietary diversity support previous research. With a startling 15.1 percentage point decrease in low dietary diversity and compensatory gains in medium and high diversity categories, high-risk households are more than twice as likely to be in the highest HDDS class under the non-parametric MSI criterion. This suggests a high sensitivity to changes in diet quality and availability. Effect sizes are typically smaller—roughly half the magnitude of those seen under the non-parametric definition—even though the parametric categorization likewise demonstrates statistically significant relationships with HDDS, indicating decreased sensitivity and poorer policy relevance.

In sum, high-risk households have significantly lower food security and livelihood outcomes than low-risk households, according to multivariate analysis. Despite some elevation in medium/high categories under stress, high-risk households are much more likely to adopt severe coping strategies, have higher probabilities of severe/very severe hunger and crisis-level rCSI, have significantly lower chances of an acceptable FCS or no hunger, and have lower probabilities of high dietary diversity.

High-risk households show a much greater propensity to rely on very severe or emergency forms of livelihood coping and crisis levels of consumption coping and experience very severe levels of hunger, poorer consumption scores, and changes to dietary diversity that are driven by stress, even after adjusting for rigorous models based on demographics, livelihood, living arrangements, and geography.

What this implies is that the MSI is effective and efficient in identifying the most vulnerable households impacted by shock episodes, and that the non-parametric method is highly correlated, which is not surprising given its baseline sensitivity to high exposure levels. Nevertheless, it is evident that vulnerability is highly condensed, and high values on the MSI indicate severe vulnerability, which necessitates shock-sensitive safety net programs, emergency services, and strengthening the resilience of highly impacted households in the Somali context.

Table 11: Association of high risk exposure and food security outcomes

	Non Parametric, high_risk_75		Parametric, high_mean+SD	
Category	Relative Risk Ratios (RRR)	Average Marginal Effects (Percentage Points)	Relative Risk Ratios (RRR)	Average Marginal Effects
No coping	Base outcome	-3.13 (0.001)	base	-1.97 (0.007)
Stress coping	3.39 (0.001)	-0.70 (0.345)	2.05 (0.086)	-1.43 (0.105)
Crisis coping	3.93 (0.001)	0.01 (0.099)	2.78 (0.008)	0.21 (0.887)
Emergency coping	4.18 (0.001)	3.82 (0.011)	2.89 (0.005)	3.20 (0.058)
low	base	--2.17 (0.004)	base	-0.96 (0.206)
Medium (stressed)	1.55 (0.021)	-2.33 (0.138)	1.25 (0.288)	-0.71 (0.690)
High (crisis and more)	1.81 (0.001)	4.50(0.005)	1.31 (0.181)	1.66 (0.362)
Poor FCS	Base	10.59 (0.001)	Base	2.46 (0.178)
Borderline	0.69 (0.001)	2.25 (0.122)	0.88 (0.222)	-1.39 (0.401)
Acceptable	0.47 (0.001)	-12.84 (0.001)	0.91 (0.291)	-1.07 (0.556)
No Hunger	base	-8.67 (0.001)	Base	-4.56 (0.004)
Slight hunger	1.39 (0.007)	-1.83 (0.136)	1.31 (0.004)	0.58 (0.678)
Moderate hunger	2.05 (0.001)	-5.99 (0.001)	1.30 (0.031)	0.61 (0.700)
Severe hunger	1.96 (0.015)	6.78 (0.001)	1.56 (0.001)	6.10 (0.001)
Very Severe hunger	1.49 (0.015)	-0.34 (0.661)	1.09 (0.623)	-1.15 (0.246)
Low Dietary Diversity	base	-15.06 (0.001)	base	-7.61 (0.001)
Medium Dietary Diversity	1.92 (0.001)	5.46(0.001)	1.39 (0.01)	2.66 (0.152)
High Dietary Diversity	2.31 (0.001)	9.60 (0.001)	1.54 (0.001)	4.95 (0.004)

The Interaction-Shock Analysis and Food Consumption Score Elasticity

The percentage change in household FCS linked to the existence of combined shocks is displayed in Table 12, which displays elasticities from a log-log regression model. The reported elasticities approximate the percentage change in FCS when both shocks occur simultaneously because the model uses the logarithm of FCS as the dependent variable and likely binary indicators for shock combinations, capturing interaction effects beyond the individual contributions of each shock. While a positive elasticity implies that the combination is linked to a slight increase in food consumption, a negative elasticity shows that a particular combination of shocks is linked to a decline in household food security.

The findings show that food price shocks had the greatest detrimental impact on FCS, especially when paired with job loss or animal illness. The compounding effects of lower income and interrupted food availability on dietary diversity and frequency of intake are demonstrated, for example, by combinations of higher food costs with lost work or animal disease, which show substantially negative and statistically significant elasticities. On the other hand, combinations like increased fuel prices and movement restrictions exhibit positive elasticities, indicating that households may use adaptive strategies that preserve or even increase food consumption in comparison to dealing with the shocks separately, such as resource substitution or relying on stored supplies.

The shocks most closely linked to decreases in FCS across all combinations are job loss and plant or animal illnesses. These shocks have the biggest and most detrimental influence on food intake because they either directly lower household income or restrict access to necessary food sources. On the other hand, shocks like increased fuel costs or travel limitations typically have smaller correlations with FCS, and the effects that are seen frequently reflect coping strategies used by households rather than a direct decline in food security. Small positive elasticities are seen in some combinations involving other economic shocks, which probably represent mitigation techniques like social support or alternate sources of income.

The amplification effect of concurrent crises is demonstrated by several overlapping shocks, such as pest outbreaks coupled with plant diseases or intra-household economic shocks associated with other economic shocks, which also show large negative repercussions. This trend emphasizes how shock combinations are most significant when they impact several food security channels at once. In particular, significant consequences occur when shocks simultaneously lower household income (demand side) and interfere with food production or availability (supply side), or when the household's coping mechanisms—such as savings, other sources of income, or social support—are insufficient to withstand the impact. Because they simultaneously impact several channels that determine food security, some shock combinations have a greater impact on household food consumption. When shocks happen in tandem, their impacts are not only additive; they can reinforce one another and have greater detrimental effects on households than any one shock alone could via the following channels:

Income and purchasing power are important channels. The availability of food and the household's capacity to buy it are both diminished by combinations like increased food costs and job loss. In these situations, households experience a decrease in income and an increase in market prices, which results in a combined negative impact on food consumption that is far more potent than either shock alone. The production and availability of food is another important avenue. In addition to limiting access to basic food supplies like meat and milk, shocks like animal sickness and high food prices also raise market costs, further restricting consumption. In a similar vein, pest outbreaks combined with plant diseases can destroy domestic crops, hence reducing the amount and quality of food that can be consumed. Lastly, the effects of several shocks are made worse by a restricted ability to cope. Households that experience several shocks might not have enough savings, resources, or other sources of income to lessen the impact. Aid or social networks might not be sufficient to make up for it, making households more susceptible to drops in food security.

Table 12: Elasticity of FCS with respect to the combination of shocks (log-log form)

Combined Shocks	Elasticity	P>t	Combined Shocks	Elasticity	P>t
Higher food prices & higher fuel prices	-0.018	0.28	movement restrictions & plant disease	0.04	0.08*
Higher food prices & movement restrictions	-0.018	0.37	movement restrictions & lost employment work	-0.035	0.28
Higher food prices & other economic shocks	0.036	0.00**	Other economic shock & pest outbreak	0.018	0.3
Higher food prices & animal disease	-0.082	0.00**	Other economic shocks & plant disease	0.028	0.13
Higher food prices & Napasture	-0.029	0.1	Pest outbreak & plant disease	-0.025	0.02**
Higher food prices & lost employment work	-0.100	0.00**	Napasture & movement restrictions	-0.008	0.7
Higher fuel prices & movement restrictions	0.110	0.00**	Lost employment, work & other economic shocks	0.021	0.13
Higher fuel prices & other economic shocks	-0.014	0.57	Other intra-HH shock & higher food prices	0.003	0.89
Higher fuel prices & plant disease	0.0001	0.99	Other intra-HH shock & higher fuel prices	0.032	0.3
Higher fuel prices & lost employment work	0.046	0.08*	Other intra-HH shock & movement restrictions	0.02	0.38
movement restrictions & other economic shocks	0.013	0.49	Other intra-HH shock & other economic shock	-0.029	0.02**

Testing Non-Linear Interactions and Amplification Effects of the Multi-Shock Index

Food security may be somewhat impacted by individual shocks, but when several shocks occur simultaneously, the effects may be non-linear or exacerbated, suggesting interaction effects larger than the sum of their individual components. Determining the worst risk scenarios and understanding how households are fully vulnerable requires testing of this non-linearity. There are various approaches to test for non-linear effects in the interaction of MSI. There are accelerating or decelerating effects when quadratic or higher-order terms are added. A positive coefficient on a squared term would indicate amplification, meaning that the additional marginal impact increases as MSI values rise. Highly vulnerable households that live at high thresholds of vulnerability can be identified through empirical testing of MSI non-linearity. In this regard, households experiencing the highest levels of compound shock could be given priority for solutions by authorities. The discovery of amplification effects highlights several reasons why social protection, food assistance, and resilience-building programs should take into account shock interaction rather than a single shock.

Using a log-linear model, the regression analysis evaluated the impact of households' cumulative shocks, as determined by the parametric MSI created by the literature study, on the FCS. Variables about household characteristics, including gender, education, marital status, and involvement in agriculture-related activities, were taken into account by the regression model. To make the nonlinear effect simpler to comprehend, the MSI was rescaled between 0 and 100. If not, the range of the parametric MSI scale is 0 to 1. MSI_PSQ, the quadratic term, is therefore scaled from 0 to 1. Because the squared term is scaled between 0 and 1, which narrows the range, its impact will be proportionately tiny even though it is statistically significant. As a result, the graph will be nearly linear. Additionally, there will be a mathematical amplification effect. As a result, the MSI was rescaled from 0 to 100. Additionally, the models are found to be resilient after the diagnostic tests are conducted. Tables 13 and Figure 5 below show the regression analysis's outcome.

The parametric MSI has a statistically significant negative linear effect on log FCS, according to Model I results, suggesting that higher cumulative shock exposure is linked to decreased household food intake. Crucially, non-linear amplification is demonstrated by the positive and substantial squared term, which implies that the marginal negative impact of shocks rises as total shock exposure grows.

On the other hand, although the quadratic term is not statistically significant, Model II reveals a strong negative linear connection between the non-parametric MSI and log FCS. This suggests that although cumulative shocks lower food security, statistically significant amplification effects are not captured by the non-parametric MSI. Overall, the findings imply that parametric MSI measures are more appropriate for identifying compounding and non-linear shock effects on family food security.

Table 13: Effect of Multi-Shock Index (MSI) on household Food Consumption Score (log FCS) with non-linear amplification

Model I: Parametric MSI				
Log_FCS	Coefficient	Robust SE	t	P>t
MSI_ Parametric	-0.0134885	0.0039258	-3.44	0.001
MSI_Parametric_Square	0.000239	0.0000813	2.94	0.003
Model II: Non Parametric MSI				
Log_FCS	Coefficient	Robust SE	t	P>t
MSI_ Non Parametric	-0.0136231	0.0024936	-5.46	0
MSI_ Non Parametric _ Square	0.0000783	0.0000594	1.32	0.188

By visually checking the distinct U-shaped trajectory for the parametric MSI and the linear decreasing trend for the non-parametric MSI, the figure showing anticipated log (FCS) curves accurately validates these regression results.

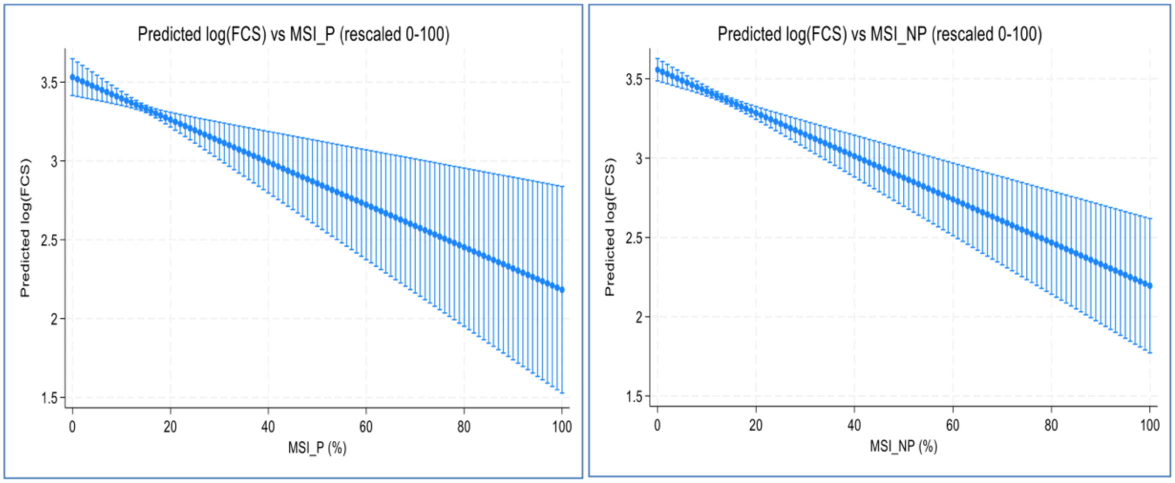

Figure 5: Predicted log (FCS) with parametric and non-parametric MSI

The findings in Table 13 have significant implications for the development of social protection and food security policies. The results show that the cumulative effect of these shocks causes a household's food consumption to decline. Crucially, this effect happens in a non-linear and cumulative manner, particularly if the effect of the shocks is measured using a parametric MSI. This means that if households are exposed to multiple events at the same time, the effect will worsen rather than add to the cumulative effect.

The significance of focused, shock-response behaviors is highlighted by the existence of amplification effects. Since shocks of this order have a significant impact on food security outcomes, households with high MSI scores should be the focus of assistance related to food assistance, cash transfer, or livelihood support. In order to determine when a household hits a vulnerability threshold before a severe food consumption indicator deteriorates, systems that evaluate cumulative exposure to shocks rather than just shock events are crucial.

The difference between the parametric and non-parametric MSI results further implies that policy targeting depends on how shocks are quantified. These parametric indices appear to be in a much better position to target households that are at risk of a quick collapse in food security because they reflect the severity and accumulation of shocks. Humanitarian and development interventions would be greatly strengthened by incorporating such indices into vulnerability assessments and targeting frameworks, particularly in situations where shocks linked to the economy, health, and climate are compounding one another.

By highlighting the non-linear joint influence of a set of food-related shocks on food security at the household level, the results shown in Table 13 close data gaps and supplement the findings from the earlier analysis of interaction-shock elasticities. An MSI analysis clearly illustrates how a group of food-related shocks collectively contribute to food insecurity, even though the interaction tables show which shocks (such as rising food costs, job loss, and animal diseases) have the worst effect on the FCS.

Table 13 demonstrates that shock exposure is highly negatively correlated with FCS across both parametric and non-parametric measures of MSI, as predicted by the interaction-shock results. Shocks to food supply and income appear to be important factors influencing food insecurity, which is consistent with other research. Nevertheless, when the number of shocks increases, the parametric MSI model also produces a statistically significant non-linear amplification effect, where the loss in food consumption increases disproportionately with each successive shock. This finding provides a structural explanation for the extremely high negative elasticities of some of the interaction terms in the interaction tables above.

In contrast, rather than detecting statistically significant escalation, the non-parametric MSI quantifies the overall impact of numerous shocks. This is consistent with the results observed in the interaction-shock matrix, where certain interactions show negligible or statistically insignificant effects. When combined, these results show that while most combinations of shocks have minimal marginal effect, powerful or recurrent shocks—especially those recorded by parametric indicators—are the root causes of abrupt drops in food security.

The combined analysis of interaction-shock and the MSI non-linear models provides a consistent story, in which the key high-energy shock combinations determine vulnerability mechanisms, the MSI model being sensitive to the mechanism accumulations as households experience more than one shock at a time. This provides a consistent message of the need for post-crisis policies to target beyond the one-off shock approach to ones that are attuned to the clustering of more than one shock, especially as a household reaches a threshold of high exposure.

Conclusion and Policy Implications

Conclusion

Households in Somalia are particularly susceptible to a variety of interconnected shocks, such as extreme weather, unstable economies, violence, and medical emergencies. Droughts and rising food costs were mentioned by 31.7 percent and 24.6 percent of households, respectively, while about 27 percent of households said they had experienced at least one significant shock. With up to 21 different types of shocks documented, compound shocks are prevalent in Awdal, Sool, and the Middle Juba regions, demonstrating the unequal distribution of risk throughout the nation. Even single incidents can significantly impact household resilience, as evidenced by the disproportionate disruption of mobility, market access, and livelihoods caused by conflict-related shocks, despite their lower frequency (6.8 percent).

Food insecurity is serious and pervasive. The FIES reports that 70 percent of households have low to medium dietary diversity, indicating inadequate consumption of nutrient-dense foods such as fruits, vegetables, and proteins, while 54 percent of households suffer from severe food insecurity. Food Consumption Scores (FCS) are consistently lower among vulnerable populations, such as IDPs, refugees, non-agricultural households, and homes led by people with only informal or religious schooling. Food security results are also greatly influenced by socioeconomic factors, such as education, type of dwelling, and diversity of livelihoods. Increased vulnerability is closely linked to displacement and low educational achievement.

The severity of the crisis is further demonstrated by household coping mechanisms. Most rely on severe or crisis tactics that compromise long-term resilience, like lowering the frequency of meals or depleting productive assets. For example, the Livelihood Coping Strategy Index (LCSI) shows that while just 2.37 percent of households maintain food security, 74.43 percent of households utilize emergency methods. Similarly, 64.05 percent of households experience high-crisis or worse circumstances, according to the Reduced Coping Strategy Index. These results highlight how the most vulnerable households suffer the most from shocks and frequently use coping mechanisms that jeopardize their ability to recover and maintain a sustainable way of life in the future.

The Multi-Shock Index (MSI) indicates a low to moderate average cumulative shock exposure of 13.3 percent (non-parametric MSI) and 14.6 percent (parametric MSI) of the maximum exposure. However, for a subset of extremely vulnerable households, food insecurity is driven by concentrated and overlapping shocks, as indicated by substantial dispersion and right-skewness. The majority of homes have moderate exposure, while 15–25 percent are considered high-risk, highlighting the necessity of identifying extreme sensitivity that goes beyond population averages. A tiered intervention strategy is supported by combining the two MSI measures: The parametric MSI identifies households with the highest cumulative exposure for focused, high-intensity support, while the non-parametric MSI catches a larger at-risk population for community-level preventative actions.

Somalia has an unequal distribution of high-risk households. While Mudug and Lower Shabelle are more noticeable with the parametric MSI, Woqooyi Galbeed, Lower Shabelle, and Lower Juba regularly show high susceptibility under the non-parametric MSI. In order to capture both clustering and intense shock exposure, this highlights the significance of region-specific targeting and the complementary use of both MSI measurements. Risk is also influenced by socio-demographic and livelihood characteristics: High-risk groups are regularly overrepresented in households led by women, those with lower levels of education, bigger households, mixed agricultural livelihoods, and displaced people, including refugees, IDPs, and returnees.

High-risk households are more likely to utilize stress, crisis, or emergency coping mechanisms, have a less varied diet, and suffer from moderate to severe hunger. Elasticity analyses verify that not every combination of shocks has an equal impact on households. For example, increased food prices combined with job loss, animal illness, or other economic shocks have the most detrimental effects on FCS, while other combinations, like fuel price increases combined with movement restrictions, may have neutral or context-dependent effects. Household FCS is adversely affected by both parametric and non-parametric MSI; parametric MSI exhibits strong non-linear amplification, suggesting that the marginal effect of further shocks may diminish at high exposure levels, whereas non-parametric MSI effects are essentially linear.

In general, food insecurity in Somalia is multifaceted, persistent, and disproportionately concentrated in high-risk households. Declining nutritional quality and dependence on detrimental coping mechanisms are caused by compound shocks rather than individual incidents. These results emphasize how crucial it is to use MSI measures to identify and target the most vulnerable households, guide interventions specific to a given region and create tiered policies that combine immediate humanitarian assistance with tactics addressing structural vulnerabilities, such as access to basic infrastructure, gender inequality, education, and livelihood diversity.

Policy Implications

Shift focus from population averages to high-risk concentration: Although the averages for shock exposure are low to moderate at 13.3–14.6 percent of the maximum, the household experiencing repeated and compounded shocks should be a priority, with enhanced shock-responsive social protection, early warnings, and livelihood resilience programs. Policy intervention needs to take a targeting threshold of 25 percent of households classified as high-risk (non-parametric MSI >75th percentile, capturing shock clustering) and 15.6 percent as extreme-risk (parametric MSI >mean +1 SD, highlighting intense cumulative exposure).

Adopt a dual-index targeting strategy and Complementary interventions: Both the non-parametric MSI and parametric MSI can be utilized simultaneously for the identification of vulnerable household units; the former for overlapping moderate shocks and the latter for extreme; aiming for efficient targeting.

Design differentiated program interventions: Program interventions should be differentiated, according to the comparative advantages of the two MSI approaches, to achieve maximum coverage, efficiency, and effectiveness. Non-parametric MSI-guided programs should focus on large-scale initiatives, such as scaling-up safety nets, multi-risk insurance schemes, resilience building at the community level, and locally targeted prevention measures, to cater to the larger share of households-exactly about 25 percent displaying clustered or overlapping shocks of moderate intensity. Alternatively, parametric MSI-guided programs should focus on providing intensive, high-impact support, including unconditional cash transfers, livelihood rehabilitation, asset protection services, and humanitarian anticipatory aid, directed toward the smaller subset of households (around 15.6 percent) who face extreme cumulative exposure. This dual approach will ensure that risk is managed holistically: Wider prevention and resilience building for nascent or widespread vulnerabilities under the non-parametric lens, combined with targeted resource-intensive aid for the most acutely distressed under the parametric lens, will ensure strengthened overall shock responsiveness in Somalia's protracted crisis setting. There must be a policy to use non-parametric MSI for the rapid detection of clusters of emerging shock, local triggers, and unstable macro-level trends, while resorting to parametric MSI for the maintenance of stable, macro-level trend monitoring and long-term planning.

Regional Targeting: The targeting of shock-resonant policies at the regional level needs to correspond with regional differences in the high incidence of vulnerable households to maximize efficiency. Regions that show high prevalence rates of the non-parametric MSI, like Woqooyi Galbeed, Lower Juba, and Lower Shabelle, where higher numbers of vulnerable households are affected in clustered or overlapping shock events, require preventive interventions and resilience action in these regions on a broad scale, like community-based early warning systems, portfolios that support diversified livelihoods, and extended safety nets for vulnerable households exposed to moderate levels of shocks. Finally, regions that are characterized by higher prevalence rates of the parametric MSI, like Lower Shabelle and Mudug, where smaller numbers of extremely affected households are prevalent, require intensive, finely targeted interventions such as emergency cash transfer programs, asset protection, and livelihood rebuilding to reduce the heavy toll of cumulative shocks in these areas.

Vulnerable Population Groups: These interventions target the most vulnerable household heads, such as heads in female-headed households, heads with lower levels of education, heads in crop-livestock-generating households, and displaced persons (IDPs, returnees, and refugees).

These interventions could be social protection, livelihood diversification, and resilience-building in the communities affected by shock exposure.

Food Security and Shock-Response Interventions: Policies need to focus on vulnerable households to mitigate the negative outcomes for food security through comprehensive approaches such as shock-responsiveness in social protection, nutrition support, food assistance, cash transfers, or livelihood activities. There is a need to concentrate on the most detrimental shock interactions, like price increases for food, animal diseases, or lack of jobs.

Early Action and Proactive Resilience: The policies should focus on lessening the total exposure to shocks, especially where MSI levels are moderate to high. The nonlinear effects indicate that early prevention efforts would be more effective before people reach the highest or lowest exposure levels, which makes early warning systems important.

Research Caveat

Despite the extensive review of the exposure to different types of shocks and coping strategies at the household level, there are a number of limitations that should be underlined. First, the present research relies on data from surveys, which may be open to response bias or problems of recall, particularly in questions relating to shocks and coping behavior that have taken place at the household level. Second, though the paper implemented multiple imputation and normalization procedures to deal with missing values, these are based on assumptions concerning the missingness mechanism, and hidden factors may continue to affect the results. Third, data are cross-sectional in nature, and it is therefore impossible to infer causality between shock exposure and household responses, since temporal dynamics and longer-run impacts cannot be accounted for. Fourth, for some shocks, especially natural hazards or conflict events that are very rare, incidence is low in the data, which implies that precision in any estimated impacts for those events will be reduced. Fifth, the indices and thresholds used for the classification of high-risk households, although statistically sound, may not capture all dimensions of vulnerability, such as social networks and informal coping mechanisms, which can influence actual household resilience.

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