Household resilience to food insecurity: evidence from Tanzania and Uganda

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Abstract

Resilience has become one of the keywords in the recent scholarly and policy debates on food security. However, household resilience to food insecurity is unobservable ex ante. Therefore, the two key issues in empirical research and program implementation are how to estimate a proxy index of household resilience on the basis of observable variables and assess whether this index is a good indicator of the construct it intends to measure, i.e. household resilience. This paper contributes to this literature providing evidence based on two case studies: Tanzania and Uganda.

Specifically, the paper: (i) proposes a method to estimate a resilience index and analyses what are the most important components of household resilience, (ii) tests whether the household resilience index is a good predictor of future food security status and food security recovery capacity after a shock, and (iii) explores how idiosyncratic and covariate shocks affects resilience and household food security.

The analysis shows that: (i) in both countries adaptive capacity is the most important dimension contributing to household resilience, (ii) the resilience index positively influences future household food security status, decreases the probability of suffering a food security loss should a shock occur and speeds up the recovery after the loss occurrence, and (iii) shocks have a negative effect on food security and resilience contributes to reduce the negative impacts of these shocks, though this is not proven for self-reported and idiosyncratic shocks.

Keywords: Resilience, food security, structural equation model, panel data.

JEL classification: D10, Q18, I32, O55

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1. Introduction

Empirical evidence shows that natural, economic and political risks are on the rise with significant impacts on poverty and food security. In some tropical areas floods are increasing (Westra et al, 2013) as well as the tornado frequency and intensity because of global warming (Webster et al., 2005) and climate change is expected to significantly lower the production of rice, wheat and maize over the next decades (WB 2011; Development and Climate Change 2009; IPCC 2013) determining a likely increase of undernourished and malnourished (Wheeler and Von Braun, 2013; Lloyd et al, 2011)

Since the 2007-08 commodity price crisis, food prices have been three times more volatile and their level is on average higher than before the crisis, causing a significant increase in poverty and food insecurity (FAO, 2011). The 2008-09 global recession added some 100 million more undernourished (FAO, 2009) and despite significant progress, the current stock of undernourished worldwide is still as high as 790 million people (FAO, 2015). Some 1.5 billion people live in conflict areas (WB, 2011) and by end of 2014 some 59.5 million individuals, of which some 19.5 million refugees, were forcibly displaced worldwide as a result of persecution, conflict, generalized violence, or human rights violations: the highest recorded level in the post-World War II era (UNHCR, 2015). By 2030 a larger portion of world's impoverished will be concentrated in natural resources–based economies and fragile and conflict-affected states, especially in Sub-Saharan Africa (WB, 2016).

In short, natural, economic and political risks faced by households, farms, firms, economies, and even whole countries have been more frequent and severe over the last years (Zseleczky & Yosef, 2014)). This is probably the reason for resilience became one of the keywords of the recent policy and scholarly debates.[1]

By and large, resilience can be defined as the capacity of a system to withstand risks. Originally born in the general theory of systems, it has been later used in different fields such as ecology, engineering, psychology and epidemiology (Holling, 1996; Gunderson et al., 1997). Over the last decade it has been used also in social sciences and, specifically, in the analysis of complex systems such as socio-ecological systems.[2] More recently, some international organizations (FAO, 2012); EU Commission, 2012) proposed to use resilience to analyze food and nutrition security. In this specific field, resilience to food insecurity defines the capacity of a household to maintain a certain level of wellbeing (e.g. being food secure) notwithstanding shocks and stressors.

[1] For example, the World Bank (2012) Social Protection and Labour Strategy was called "*Resilience, Equity, Opportunity*", the World Economic Forum 2013 held in Davos focused on "*Resilient Dynamism*" and the last IFPRI 2020 Conference, held in Addis Ababa in 2014, focused on "*Building Resilience for Food and Nutrition Security*".

[2] Socio-ecological systems are systems in which the ecological and socio-economic components are closely integrated This is precisely the case of agro-food systems in developing countries, where many communities and social groups gain their livelihoods using renewable natural resources through activities such as farming, agro-forestry, and fishing.

Resilience is appealing as an analytical and policy concept because it allows understanding the determinants of vulnerability, the strategies adopted by the household to manage shocks as well as the adaptation strategies over time. Indeed resilience and vulnerability are two complementary approaches. While the latter is aimed at forecasting the occurrence of a shock, resilience evaluates the household capacity to manage the effect of a shock.

Despite the importance of the resilience concept, its use in the development field is relatively new and there is no consensus yet on how it should be measured (Barrett and Constas, 2014).[3] The issue is related to the fact that resilience to food insecurity is unobservable ex ante. Therefore, the two key issues in empirical research and program implementation are how to estimate a proxy index of household resilience on the basis of observable variables and assess whether this index is a good indicator of the construct it intends to measure, i.e. household resilience. This paper contributes to this literature providing evidence based on two case studies, Tanzania and Uganda.

In doing this, the paper uses one of the most promising approaches to quantitatively assess household resilience that is the FAO Resilience Index Measurement Analysis (RIMA). This approach uses latent variable models to estimate the resilience capacity of a given household as a function of a series of household observable characteristics (Alinovi, et al., 2010); (d'Errico, et al., 2015).

Specifically, the paper: (i) proposes a method to estimate a resilience index and analyses what are the most important components of household resilience, (ii) tests whether the household resilience index is a good predictor of future food security status and food security recovery capacity after a shock, and (iii) explores how idiosyncratic and covariate shocks affects resilience and household food security.

The paper is structured accordingly. Section 2 defines the concept of resilience and highlights the analytical framework for its measurement. Section 3 describes the data and the econometric strategy used to estimate the resilience capacity index. Section 4 analyses the different dimensions contributing to household resilience in Tanzania and Uganda. Section 5 tests how the resilience index influences future household food security attainments in the two countries. Section 6 assesses the role of idiosyncratic and covariate shocks on food security and their relationship with household resilience. Section 7 summarizes the most important findings, discussing also some policy implications.

[3] Vaitla et al. (2012, p. 5) observed that “academics and practitioners have yet to achieve a consensus on how to measure resilience”, while Frankenberger et al. (2012, p. 26) noted that the dynamic process of building resilience makes it inherently difficult to measure. The FAO-WFP-IFAD Technical Working Group on Resilience Measurement (TWG-RM, 2013) reports most of the approaches that have been recently proposed to measure resilience, including those of FAO, DFID, USAID, EC, and WFP.

2. An introduction to resilience measurement framework

Resilience is a multi-faceted phenomenon. Scholars, research centers, organizations and agencies have developed their own definitions and methods to measure it. Alinovi *et al*. (2008: 300) define resilience as "the capacity of a household to keep a certain level of wellbeing (e.g. food security), notwithstanding shocks and stresses, and reorganize while undergoing change so as to still retain essentially the same function, structure, identity". More recently, the Technical Working Group on Resilience Measurement (FSIN, 2013: 6) defines resilience as "the capacity that ensures adverse stressors and shocks do not have long-lasting adverse development consequences".

These definitions imply that: (i) resilience is an outcome-based concept, being the outcome a measure of poverty, food security (as in this paper) or any other indicator of well-being; and (ii) unlike similar concepts (e.g. vulnerability), resilience emphasizes long-lasting effects on the outcome variable at hand as well as agency, that is the agent's capacity to absorb, adapt and transform livelihood strategies to offset the (anticipated or actual) negative impacts of shock.

Therefore, any modeling/measurement effort should be able to capture these features, which implies the following:

- resilience has to be benchmarked to an outcome: the dependent variable measuring how resilient the agent (being it an individual, a household, a community, etc.) is in facing a shock must be a measure of his status with reference to a given output level normatively established (e.g. poverty line, minimum food caloric intake, etc.);
- resilience is a genuinely dynamic concept: it involves the complex process of preparing and responding to shocks. Furthermore, it is defined with reference to the "long-lasting" consequences of a given shock. This implies that the analytical framework cannot be static and appropriate time intervals and appropriate durations must be defined;
- the analytical framework must be able to capture all possible pathways to ensure resilience: these pathways may be very different across agents even if they live in the same area. As a result, the analytical framework must be able to capture the causal relationship linking risks and outcomes (risk chain) and account for agents' heterogeneity in gaining a livelihood.

Measuring resilience requires dealing with the issue of choosing the proper scale and the time frame at which carry out the analysis (and the implications thereof).

The scale of analysis depends on the objectives of the analysis and it is relevant to define the indicator to be used for measuring resilience. In many cases the households is the most suitable entry point for the analysis of resilience.[4] In the specific case of food, a suitable indicator of

[4] In fact, as decision-making unit, the household is the unit within which the most important decisions to manage risks, both ex-ante and ex-post, including the ones affecting food security, are made: e.g., what income-generating activities to engage in, how to allocate food and non-food consumption among household members, what strategies to implement to manage and cope with risks, etc.

wellbeing is the household food consumption at different points in time or the change in food consumption between two points in time.[5]

However, adopting a household perspective does not mean disregarding the importance of the relationships between the households and the broader system they belong to (e.g. the community, the district, etc.). Rather, this means acknowledging that systems comprise hierarchies, each level of which involves a different temporal and spatial scale (Gunderson and Holling, 2002). Therefore, considering different levels of analysis – say food security at community level or district level or even at higher hierarchical level (province or state) - implies that the dependent variable indicator may be different. For instance, in analysing the food security at country level, a suitable indicator is the percapita caloric availability computed from the country food balance sheets, while if the analysis is a household level a suitable indicator is the food caloric intake, the dietary diversity, the food consumption score, etc.[6]

This also implies acknowledging that the broader system contributes to determine the household performances in terms of food security, including its resilience to food insecurity. Operationally, this implies that the characteristics of the broader system the household belongs to should be explicitly accounted for in the analytical framework and in the model.

The time frame relevant for the analysis also depends on the analytical objectives at hand. Specifically, it depends on the scale at which the analysis is carried out and on the livelihood strategies adopted by a given household (which in turn define both the risk landscape it lives in and options available to manage risks). Generally speaking, the longer the time period covered by the analysis the better for assessing the household ability to recover to a wellbeing level it enjoyed before the shock occurred.

The issue of how short should be the minimum time frame for a meaningful analysis depends on the household livelihood strategy. Indeed, the strategies implemented by pastoralists or farmers are completely different from the ones of rickshaw paddlers or urban wage earners in terms of speed of income generating and asset building as well as in terms of time pattern (e.g. seasonal or not seasonal). Operationally, this means firstly that the model should explicitly control for heterogeneity in livelihood strategies and secondly that the time frame should be long enough to give the household a chance for recovering: more often than not, this means considering an analytical time frame spanning at least a few years.

In short, scale and time frame are very important because they define: (i) the system to be analysed (a household, a community, the whole population of a country), (ii) the variable measuring the status of the system (a wellbeing indicator), and (iii) the variables that influence the system status. Therefore, a very general analytical structure can be thought of as a

[5] However, there is no reason whatsoever to restrict the analysis of resilience to this indicator: any wellbeing indicator at household level can be used, e.g. nutritional or health status indicators will work as well (cf. Hoddinott and Kinsey, 2002).

[6] Consequently, the analytical model needs to be modified to account for these changes in the dependent variable. For instance, the higher the level of analysis the more important covariant shocks (at the proper scale) rather than idiosyncratic shocks. Usually, this also translates into a longer time frame for the analysis.

relationship between a dependent variable, Y, indicating the system status, and some independent variables, X_i, (i = 1, ..., n) that have an impact on this status:

$$Y = f\left(X_1, X_2, \ldots, X_n\right). \tag{1}$$

Our assumption is that there are some characteristics (household or context specific) that make a given household more resilient than others to the same shock. Hence, it is crucial to identify what are the attributes of this resilience "capacity":

$$Y = f\left[R\left(X_1, X_2, \ldots, X_m\right), X_{m+1}, X_{m+2}, \ldots, X_n\right], \tag{2}$$

where variables 1 to m are resilience correlates, which in turn impact the status Y (e.g. food security), while variables $m + 1$ to n are other variables that impact Y, though they do not influence household resilience, R.

The analytical challenge is how to measure such a "capacity", R, and how to estimate the relation (2), that links resilience as well as other determinants to the outcome status. This is the overall objective of this paper.

3. Data and methods

3.1. Data

This paper uses two panel datasets from the World Bank's Living Standard Measurement Studies Integrated Survey on Agriculture (LSMS-ISA) both covering three rounds: the Tanzania National Panel Survey (TZNPS: 2008-09, 2010-11 and 2012-13) and the Uganda National Household Survey (UNHS: 2009-10, 2010-11 and 2011-12). These datasets are nationally representative and represent a unique opportunity to study and compare household resilience across diverse contexts. In fact, in each LSMS-ISA country a multi-purpose household questionnaire is administered to all sampled households. Furthermore, agricultural households are provided with an additional module that collects detailed agricultural information.[7]

Table 1 shows the frequencies of households experiencing different food security evolutions over time in the two countries. 50 percent and 39 percent of respectively Ugandan and Tanzanian households experienced a loss in food caloric intake between time $t1$ and $t2$.[8] Among

[7] Summary statistics for all the variables used in the analysis are reported in table 9 in annex.

[8] In the following analysis only significant changes in households' food security status are considered, establishing a 5 percent threshold as lower bound to food security fluctuations. Therefore, we define a food security loss between time 1

the households who suffered a loss between time *t1* and time *t*2, 73 percent were able to recover the loss between time *t*2 and *t*3 in Uganda while only 61 percent did so in Tanzania. The share of households suffering a loss in dietary diversity is 70 percent in Uganda and 51 percent in Tanzania between *t1* and *t2*; of those respectively 50 percent and 58 percent recovered the loss between time *t*2 and *t*3.

Table 1. Food security patterns among Ugandan and Tanzanian households

	Uganda		**Tanzania**	
	Frequency	Percent	Frequency	Percent
Total households	1,928		2,867	
Suffering a loss in **food caloric intake** between time *t* and *t*+1	969	50.26	1,146	39.97
Recovering the loss in food caloric intake between time *t*+1 and *t*+2	710	73.27	703	61.34
Suffering a loss in **dietary diversity** between time *t* and *t*+1	1,350	70.02	1,483	51.71
Recovering the loss in dietary diversity intake between time *t*+1 and *t*+2	514	50.67	865	58.33

In order to explore how idiosyncratic and covariate shocks affects resilience, two additional datasets were merged with LSMS – ISA by using the geographic localization of the households. A climatic dataset (Arslan et al., 2015) including geo-referenced environmental variables (e.g. aridity index, night-time lights, climatic data, etc.) was used to describe local conditions and to build natural shock variables by using the coefficient of rainfall variation.[9] A second dataset, which provides long-term (1997-2014) and current (2015) data on conflict episodes for African countries (Carlsen et al., 2010),[10] was used to build a violence intensity index by aggregating events of violence in a given year and discounting them by their distances from where the household lives (Bozzoli et al., 2011).

3.2. Methods

Resilience is a multi-faceted concept that is not directly observable. Consequently it has to be measured through a proxy. This paper adopts the FAO's Resilience Index Measurement Analysis model (RIMA, see Alinovi et al., 2008 and 2010; FAO, 2013) that quantitatively assesses household resilience through latent variable modeling.

The RIMA approach is based on a two-stage procedure (FAO 2016). In the first step, factor analysis (FA) is used to identify the attributes – called 'pillars' in the RIMA jargon – that

and 2 only if the household food security indicator in time 2 is less than its value in time 1 minus 5 percent. Consistently, we consider that a household recovers the loss suffered between tome 1 and 2 if its food security indicator in time 3 is greater or equal than its value in time 1 minus 5 percent.

[9] The coefficient of rainfall variation is equal to the ratio of the long-term (1983-2012) standard deviation of rainfall over the long-term average rainfall.

[10] For each conflict episode, the dataset reports the date of the event, the type of the event, the actors involved, geographical information on where the event happened (description of exact location, latitude and longitude), number of fatalities and the source of information.

contribute to household resilience, starting from observed variables. These attributes are: access to basic services (ABS), assets (AST), social safety net (SSN) and adaptive capacity (AC).[11] In the second step, a multiple indicators multiple causes (MIMIC) model is estimated. Specifically, a system of equations is constructed, specifying the relationships between an unobservable latent variable (resilience), a set of outcome indicators (food security indicators),[12] and a set of attributes (pillars).

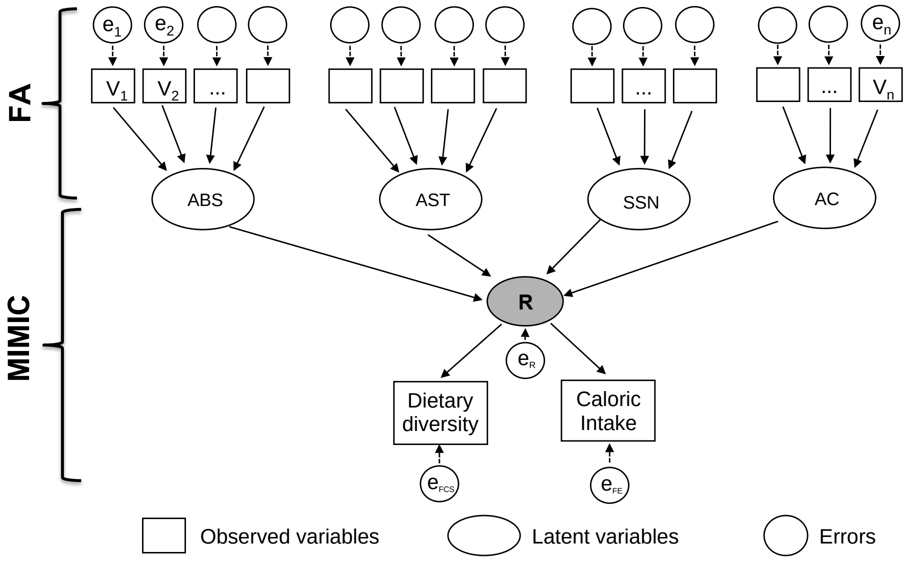

Figure 1. Resilience index estimation strategy

The MIMIC model is made by two components, namely the measurement equation (3), reflecting that the observed indicators of food security are imperfect indicators of resilience capacity, and the structural equation (4), which correlates the estimated attributes to resilience capacity:

$$\begin{bmatrix} Food\ expenditure \\ \\ Dietary\ diversity \end{bmatrix} = [\Lambda_1, \Lambda_2] \times [RCI] + [\varepsilon_2, \varepsilon_3] \quad (3)$$

$$[RCI] = [\beta_1, \beta_2] \times \begin{bmatrix} ABS \\ AST \\ SSN \\ AC \end{bmatrix} + [\varepsilon_1]\,. \quad (4)$$

[11] Annex 1 reports the list of observed variables, and their summary statistics, used to estimate the attributes. The factors considered for each attribute are only the ones able to explain at least 95 percent of the variable variance.

[12] The food security indicators used in this paper have been selected to capture both qualitative and quantitative dimensions of individuals' diet, that are the Shannon index of dietary diversity and the food caloric intake, respectively. Some other food security indicators – food expenditure, food consumption score – have been used to test the robustness of the estimates. All these indicators have been selected according to the empirical literature (Pangaribowo, et al., 2013).

The index representing the latent variable RCI[13] is jointly estimated by its correlates and outcome indicators. The estimated resilience capacity index (RCI) is not anchored to any scale of measurement. Therefore, a scale has been defined setting equal to 1 the coefficient (Λ_1) of food expenditure loading, meaning that one standard deviation increase in Res implies an increase of 1 standard deviation in food expenditure. This defines also the unit of measure of the other outcome indicator (Λ_2) and for the variance of the two food security indicators:

$$Food\ expenditure = \Lambda_1 RCI + \varepsilon_2 \quad (5)$$

$$Dietary\ diversity = \Lambda_2 RCI + \varepsilon_3 \quad (6)$$

4. Correlates of resilience

The MIMIC model provides two outputs: an estimate of the resilience capacity index (RCI) and the resilience structure matrix (RSM), which describes how different attributes correlate with resilience (Table 2).

Table 2 MIMIC results

VARIABLES	(1) **Uganda**	(2) **Tanzania**
ABS	0.113***	0.338***
	(0.0140)	(0.0211)
AST	0.0898***	0.0594***
	(0.0130)	(0.0131)
SSN	0.0416***	0.193***
	(0.0209)	(0.0215)
AC	0.218***	0.285***
	(0.0183)	(0.0135)
Food expenditure	1	1
	(0)	(0)
Dietary diversity	1.001***	0.847***
	(0.0881)	(0.0353)
Chi2	71.59	5.52
P value	0.0000	0.1377
RMSEA	0.029	0.010
Pr RMSEA	0.996	1.000
CFI	0.923	0.999
TLI	0.769	0.998
Observations	6,387	8,604

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[13] Automatically, from the statistical software employed.

All attributes are statistically significant. However, adaptive capacity and access to basic services are the two attributes more strongly correlated to resilience (Figure 1).

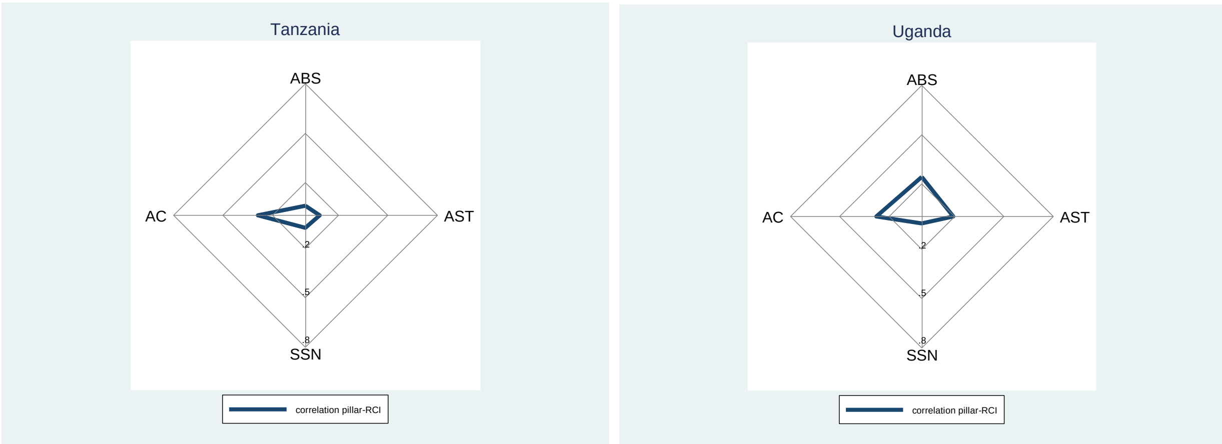

Figure 2. Attributes correlation to resilience

Figures from 2 to 4and Table 3 analyze what are the most relevant variables by attribute in each country. For ABS, the distance to school is the most relevant variable in both countries. In terms of AST, the wealth index and TLU play the most relevant roles in Tanzania and Uganda, respectively. For AC, education and dependency ratio are the most relevant variables in both countries. In terms of SSN, the private transfers are the most important variable in Tanzania, while other transfers are most important in Uganda.

Figure 1. Variables' relevance in ABS

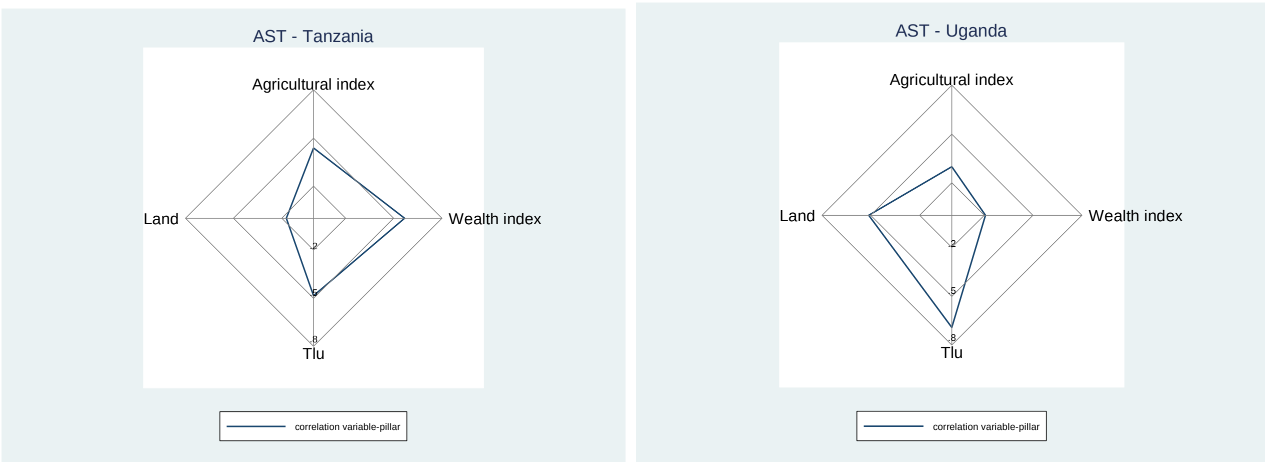

Figure 4. Variables' relevance in AST

Figure5. Variables' relevance in AC

Table 3. Variables' relevance in SSN

SSN	Uganda		Tanzania	
	FLs	Correlation	FLs	Correlation
Private transfers	0.043	0.0493	0.087	0.3507
Public or other transfers	0.028	0.0752	0.042	0.1620

5. Household resilience and food security

The relationship between resilience and food security is expected to be positive, specifically: a) a higher RCI in time *t* should be associated to better food security outcomes in time *t*+1, and b) should a food security loss occur between *t1* and *t2* as a result of a shock, a higher RCI in time *t1* should be associated to a faster recovery between time *t2* and *t3*. The latter can be very helpful in the likely cases where cross-sectional data only are available; this ultimately may turn into the adoption of the RCI as a predictor of food security.

In order to test these relationships, the RCI can be regressed on food security outcomes, controlling for a series of other variables that can have an impact on food security attainments. We use as indicators of food security an index capturing the quantitative dimension food security, i.e. percapita caloric intake, as well as a proxy for diet quality, i.e. the Shannon dietary diversity.[14] In order to compare the resilience levels across different periods, the resilience capacity index has been standardized through a Min-Max scaling transformation.[15]

5.1. Household resilience and food security attainments

The relationship between household resilience and food security attainment has been tested through the following a fixed effects (FE) regression model:[16]

$$FS_{h,t} = \alpha_h + \beta RCI_{h,t} + \boldsymbol{\gamma}\mathbf{X}_{h,t} + \varepsilon_{h,t} \quad (7)$$

where the food security outcomes in time t are represented alternatively by the percapita food caloric intake and the Shannon dietary diversity index ; RCI is the resilience capacity index for household h in time t; $\mathbf{X}$ is a vector of time-varying household characteristics; ε is the usual error term and α_h are household fixed-effects.

Table 4 shows the results of FE models of resilience capacity index and controls on food security indicators for Tanzanian and Ugandan households, respectively. The resilience index is a good predictor of household food security**.** The relationship between the resilience capacity index and the two indicators of food security is positive and statistically significant in both countries. This relationship is robust to different specifications such as using alternative food security

[14] The percapita caloric intake is computed after converting all the consumed food items (from the food consumption module of LSMS-ISA surveys) expressed in kilograms into calories. The sum of all the consumed calories represents the caloric intake. The latter is expressed in daily and per capita terms. The Shannon dietary diversity index is computed by considering the shares of the consumed calories by group of food (cereals, roots, vegetables, fruits, meat, legumes, dairy, fats and other).Specifically, the adopted formula is the following:

$$Dietary\ diversity = -\sum_{i=1}^{n} p_i * ln p_i$$

Where p_i expresses is the share of consumed calories of group *i* in a sample of *n* food groups.

Additional details on the difference diversity index can be found in (Keylock, 2005).

[15] The Min-Max scaling is based on the following formula: $RCI_h^* = \frac{(RCI_h - RCI_{min})}{(RCI_{max} - RCI_{min})} * 100$.

[16] A FE model is very suitable for this analysis because it yields a consistent estimate of the marginal effect of the RCI, even if the regressors are endogenous (Cameron and Trivedi, 2009). Indeed, in the FE model the α_h may be correlated with the regressors. This is the case if, for example, household unobservable ability is correlated both with household resilience capacity and its food security.

indicators – we tested it using percapita food expenditure and the food consumption score (FCS)[17] – or replacing the control variables by their inter-temporal mean.[18]

As expected, the household size is negatively correlated to percapita caloric intake, indicating that on average the larger the household the less quantity of food for each household member, while it is positively correlated to diet diversity, may due to the fact that the larger the household the more different the sources of food. The square of household size has opposite sign to the simple household size, indicating that the impact of the later is a marginally decreasing with household size.

Table 4. Fixed effect regression of RCI on dietary diversity index and percapita caloric intake

	Tanzania		Uganda	
	(1)	(2)	(3)	(4)
	Shannon dietary diversity	**Percapita caloric intake**	**Shannon dietary diversity**	**Percapita caloric intake**
RCI	0.0213***	39.32***	0.0450***	85.92***
	(0.000275)	(0.872)	(0.000664)	(3.691)
Female HH head	-0.00156	52.56	0.0198	215.1
	(0.0156)	(49.51)	(0.0292)	(162.4)
Age of HH head	-0.0015**	1.028	-0.00102	-0.809
	(0.00063)	(1.987)	(0.00108)	(6.027)
HH size	0.0180***	-69.57***	0.104***	-74.97*
	(0.00343)	(10.86)	(0.00701)	(38.97)
Sq. HH size	-0.0004**	1.952***	-0.003***	-3.609
	(0.00018)	(0.558)	(0.0005)	(2.517)
Rural	0.0189*	52.56	0.0130	218.1
	(0.0114)	(49.51)	(0.0514)	(285.7)
Year1	-0.049***	206.7***	-0.113***	328.8***
	(0.005)	(15.94)	(0.008)	(45.71)
Year2	-0.068***	144.1***	-0.216***	741.8***
	(0.00533)	(16.90)	(0.00820)	(45.58)
Constant	0.487**	1,001	0.0616	417.5
	(0.214)	(678.2)	(0.113)	(626.9)
Obs.	8,601	8,601	5,784	5,784
R-squared	0.535	0.535	0.650	0.650
N. of households	2,867	2,867	1,928	1,928

Household fixed effects are controlled for in all models.
Regional dummies are included as control: 26 dummies in models (1) and (2) and 4 dummies in models (3) and (4).
Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

[17] FCS is a score calculated using the frequency of consumption of different food groups consumed by the household during the 7 days before the survey. The weights are standard and can be employed in all analyses (WFP, 2008).

[18] However, if the RCI is replaced with all the covariates used for estimating RCI, the predicted capacity of the model decreases. This as well as all other additional tests can be provided upon request by the authors.

5.2. Household resilience, food security loss and the speed of recovery

Another possibility to explore the relationship between resilience and food security is the estimation of a probit model where the probability of suffering a loss in food security outcome (dietary diversity or food caloric intake)[19] between time $t1$ and $t2$ depends on the resilience capacity index (RCI) in t and a vector of household characteristics **X**:

$$Prob\big(loss\ in\ FS_{t1,t2}\big) = \Phi(\beta RCI_{h,t1}, \boldsymbol{\gamma}\mathbf{X}_{h,t1})\ . \qquad (8)$$

Furthermore, the probability of recovering between time $t2$ and $t3$ can be assessed using again a probit model as in eq. (8) applied to the sub-sample of households who registered a loss between $t1$ and $t2$.

Table 5. Probit regression on the likelihood of suffering a food dietary loss between $t1$ and $t2$ and recovering from the loss between $t2$ and $t3$

	Tanzania		Uganda	
	(1) Loss btw $t1$ and $t2$	(2) Recovery btw $t2$ and $t3$	(3) Loss btw $t1$ and $t2$	(4) Recovery btw $t2$ and $t3$
RCI t1	-0.0223***	0.00477	-0.0144**	0.0204***
	(0.00333)	(0.00380)	(0.00604)	(0.00575)
Shannon dietary diversity index	2.934***	-2.350***	2.149***	-1.659***
	(0.145)	(0.169)	(0.139)	(0.110)
Female HH head	0.0411	0.0404	0.164**	-0.101
	(0.0626)	(0.0879)	(0.0766)	(0.0834)
Age of HH head	-0.000392	0.00196	0.00115	0.00221
	(0.00175)	(0.00248)	(0.00228)	(0.00256)
HH size	0.00469	-0.0331	-0.104***	0.0608
	(0.0183)	(0.0426)	(0.0350)	(0.0435)
Squared HH size	-0.000163	0.00241	0.00394*	-0.00275
	(0.000907)	(0.00296)	(0.00228)	(0.00307)
Rural	0.282***	-0.214**	0.140	-0.0225
	(0.0687)	(0.0955)	(0.0942)	(0.102)
Constant	-4.276***	2.901***	-1.811***	1.113***
	(0.266)	(0.444)	(0.247)	(0.305)
Observations	2,867	1,483	1,928	1,350

All explanatory variables are at time $t1$ except dietary diversity in models (2) and (4), which are at time $t2$

Regional dummies are included as control: 26 dummies in models (1) and (2) and 4 dummies in models (3) and (4).
Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 6. Probit regression on the likelihood of suffering a food caloric intake loss between $t1$ and $t2$ and recovering from the loss between $t2$ and $t3$

	Tanzania	Uganda

[19] Alternative outcome variables used are the probability of suffering a loss in food expenditure and FCS. Results are available upon request.

	(1) Loss btw *t1* and *t2*	(2) Recovery btw *t2* and *t3*	(3) Loss btw *t1* and *t2*	(4) Recovery btw *t2* and *t3*
RCI t1	-0.0230***	0.00248	-0.00870*	0.0234***
	(0.00292)	(0.00389)	(0.00462)	(0.00719)
Percapita caloric intake	0.00130***	-0.00102***	0.000478***	-0.000633***
	(5.21e-05)	(8.82e-05)	(3.12e-05)	(5.64e-05)
Female HH head	0.0607	0.0200	-0.0280	-0.00773
	(0.0662)	(0.1000)	(0.0694)	(0.106)
Age of HH head	-0.00374**	0.00361	-0.00548***	0.00432
	(0.00190)	(0.00282)	(0.00210)	(0.00335)
HH size	0.136***	-0.0909*	0.111***	0.153**
	(0.0302)	(0.0476)	(0.0334)	(0.0620)
Squared HH size	-0.00635***	0.00288	-0.00526**	-0.00870*
	(0.00201)	(0.00316)	(0.00238)	(0.00466)
Rural	-0.0464	-0.109	-0.0937	0.344***
	(0.0720)	(0.110)	(0.0853)	(0.123)
Constant	-2.296***	1.879***	-1.063***	0.218
	(0.260)	(0.433)	(0.226)	(0.383)
Observations	2,867	1,146	1,928	969

All explanatory variables are at time *t1* except caloric intake in models (2) and (4), which are at time *t2*.

Regional dummies are included as control: 26 dummies in models (1) and (2) and 4 dummies in models (3) and (4).
Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Tables 5 and 6 show the results of the probit model of suffering a reduction of dietary diversity and food caloric intake, respectively, for Tanzania and Uganda. The RCI of time *t1* negatively affects the probability of suffering a loss in dietary diversity in both countries. Vice versa, the RCI positively affects the probability of recovering between time *t2* and *t3* in the case of Uganda, while although positive it is not statistically significant for Tanzania. The same pattern emerges for the food caloric intake.

6. The role of idiosyncratic and covariate shocks

Despite constant country-specific characteristics, household- and context- specific events may influence household resilience capacity and eventually food security outcomes. Therefore, both idiosyncratic and covariate shocks may play a role in explaining food security outcomes. In order to explore the role of these shocks are included in model (7) as follows:

$$FS_{h,t} = \alpha_h + \beta RCI_{h,t} + \boldsymbol{\gamma}\mathbf{X}_{h,t} + \delta S_{h,t} + \theta RCI_{h,t} S_{h,t} + \varepsilon_{h,t} \quad (9)$$

where S is a vector of covariate and idiosyncratic shocks. Furthermore, the interaction term between the RCI and the shock variable is included in the model with the aim to capture the marginal effect of the RCI on food security as the shock intensity increases.

The predictive capacity of RCI does not change when self-reported shock variables are included in the fixed effect model (5) and self-reported shocks are generally not statistically significant irrespective of the adopted food security indicator. This probably depends on the low quality of the information gathered as self-reported shocks.[20]

Table 7 presents the results, respectively for Tanzania and Uganda, of fixed effects models of the role of self-reported shocks in explaining food caloric intake and dietary diversity.

Table 7 FE models of the role of idiosyncratic shocks in explaining food caloric intake and dietary diversity

	Tanzania		**Uganda**	
	(1)	(2)	(3)	(4)
	Percapita caloric intake	**Shannon dietary diversity**	**Percapita caloric intake**	**Shannon dietary diversity**
RCI	**39.04***** (0.871)	**0.0212***** (0.000276)	85.55*** (3.694)	0.0451*** (0.000664)
Drought / Floods	28.16 (20.59)	-0.00539 (0.00652)	159.3*** (52.14)	0.0123 (0.00938)
Crop pest and disease	-15.11 (23.13)	0.00524 (0.00733)	-116.1 (127.5)	-0.0467** (0.0229)
Fall in price of crops	29.04 (23.65)	0.00977 (0.00749)	99.57 (138.8)	-0.0275 (0.0250)
High cost of inputs	98.29*** (24.29)	-0.0227*** (0.00770)		
Livestock shock	21.34 (23.42)	0.00476 (0.00742)		
Rise price of food	2.983 (17.61)	-0.00393 (0.00558)	-59.74 (55.25)	0.00738 (0.00993)
Business failure	-56.87 (41.46)	-0.00297 (0.0131)		
Loss of employment	-10.70 (56.53)	0.0140 (0.0179)	1.449 (73.05)	0.00438 (0.0131)
Water shortage	65.09*** (20.45)	0.00237 (0.00648)		
Illness	8.941 (31.15)	-0.00516 (0.00987)		
Death HH members	-1.006 (26.75)	0.00240 (0.00847)		
Deaths others	-9.804 (17.39)	0.0144*** (0.00551)		
Break household	-56.22 (39.65)	2.31e-05 (0.0126)		
Jail	32.27 (110.6)	0.00325 (0.0350)		
Fire	-57.96 (65.38)	-0.0210 (0.0207)	103.9 (227.9)	0.0685* (0.0410)
Robbery	32.93	-0.00754	38.53	-0.0289

[20] LSMS-ISA questionnaires include information self-reported by the respondent about the major shocks In Tanzania LSMS-ISA, section R "*Recent shocks to household welfare*" asks the household whether it has been negatively affected by a list of shocks over the past 5 years. Furthermore, for the three most significant, additional information are collected: reduction of income/assets caused by the shocks, disperison of the shocks and year of occurence. The Uganda LSMS-ISA section 16 "*Shocks and coping strategies*" collects information of the shocks occurred during the last 12 months; the lenght of the shock; the reduction in income, assets, food prodcution and food purchase due to the shock; and the strategies adopted to cope with the shock.

	(30.89)	(0.00979)	(103.4)	(0.0186)
Dwelling damage	38.61	-0.0450		
	(88.66)	(0.0281)		
Conflict			-12.68	0.0386
			(168.2)	(0.0303)
Other	172.7***	-0.00918		
	(44.97)	(0.0142)		
Female HH head	73.51	-0.00285	223.0	0.0184
	(49.83)	(0.0158)	(162.4)	(0.0292)
Age of HH head	1.355	-0.00149**	-0.325	-0.000943
	(1.992)	(0.000631)	(6.037)	(0.00109)
HH size	-74.82***	0.0185***	-74.68*	0.105***
	(10.89)	(0.00345)	(39.03)	(0.00702)
Squared HH size	2.143***	-0.000398**	-3.625	-0.00436***
	(0.558)	(0.000177)	(2.520)	(0.000453)
Rural	-1.070	0.0186	187.7	0.00762
	(35.98)	(0.0114)	(285.9)	(0.0514)
Dummy year 1	238.7***	-0.0507***	344.4***	-0.112***
	(16.96)	(0.00537)	(49.00)	(0.00881)
Dummy year 2	161.0***	-0.0671***	765.3***	-0.214***
	(17.58)	(0.00557)	(49.93)	(0.00898)
Constant	-226.1	0.741***	366.7	0.0541
	(686.1)	(0.217)	(628.0)	(0.113)
Observations	8,601	8,601	5,784	5,784
R-squared	0.306	0.537	0.177	0.651
Number of hh	2,867	2,867	1,928	1,928

Regional dummies are included in all models.
HH FE are included in all models.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Vice versa, using a between effects (BE) specification, including exogenously estimated covariate shocks – an index of violence intensity and the rainfall coefficient of variation (see section 3.1) – the results are different (Table 8).[21]

Table 8 BE models of the role of covariate shocks in explaining food caloric intake and dietary diversity

	Tanzania				Uganda			
	(1)		(2)		(3)		(4)	
	Percapita caloric intake		Dietary diversity		Percapita caloric intake		Dietary diversity	
	coefficients	dy/dx	coefficients	dy/dx	coefficients	dy/dx	coefficients	dy/dx
RCI	41.86***	**45.66*** **	0.0278***	**0.021*** **	50.90	**101.264*** **	0.0375***	**0.043*** **
	(2.517)	(0.878)	(0.00107)	(0.0003)	(32.18)	(4.431)	(0.00885)	(0.001)
Violence index	13.37	-0.102	0.0193***	0.0023	4.734	**-8.307*** **	0.00428***	**-0.002*** **
	(12.77)	(5.919)	(0.00402)	(0.0025)	(6.416)	(2.870)	(0.00162)	(0.0006)
Rainfall variation	-1,315***	**-632.986*** **	0.809***	-0.016	-2,666	2077.665	-0.474	0.234
	(411.0)	(273.606)	(0.170)	(0.0831)	(2,725)	(1059.765)	(0.751)	(0.223)

[21] Fixed effects models cannot be used because the rainfall coefficient of variation is fixed in the considered period. The results are robust to the use of random effect models.

RCI * Violence index	-0.358*	-0.000449***	-0.659***	-0.000350***
	(0.212)	(6.81e-05)	(0.228)	(5.04e-05)
RCI * Rainfall variation	18.12*	-0.0219***	239.9	0.0358
	(9.293)	(0.00379)	(148.5)	(0.0389)
Female HH head	10.72	0.00858	73.12*	0.0382***
	(17.73)	(0.00640)	(38.89)	(0.00821)
Age of HH head	2.094***	-0.000306	8.090***	0.000653**
	(0.510)	(0.000190)	(1.547)	(0.000279)
HH size	-40.80*	0.0140***	-36.55	0.0924***
	(24.57)	(0.00291)	(25.31)	(0.00674)
Squared HH size	1.131	-0.000157	-0.390	-0.00432***
	(1.682)	(0.000188)	(1.731)	(0.000501)
Rural	133.2***	0.0395***	343.5***	0.0858***
	(21.54)	(0.00834)	(69.91)	(0.0156)
Constant	492.9***	0.264***	448.3	-0.0583
	(175.1)	(0.0687)	(596.6)	(0.167)
Observations	8,601	8,601	5,784	5,784
R-squared	0.636	0.756	0.325	0.685
Number of newid	2,867	2,867	1,928	1,928

Regional dummies are included as control; specifically 26 in columns (1) and (2) and 4 in columns (3) and (4).
Robust standard errors at household level in parentheses *** p<0.01, ** p<0.05, * p<0.1
Marginal effect of RCI is calculated at the average value of violence index and rainfall variation. Marginal effect of violence intensity is calculated at the average value of RCI. Marginal effect of rainfall variation is calculated at the average value of RCI. Delta-method is employed for standard errors of marginal effects.

Looking at the marginal effects computed at the mean value of RCI, the violence index is statistically significant and has negative effect on dietary diversity as well as food caloric intake in Uganda, where the episodes of violence are a major concerns with respect to Tanzania. The coefficient of rainfall variation has a negative and statistically significant effect on caloric intake only in Tanzania.

RCI keeps its positive and statistically significance, in both countries and all indicators, when it is evaluated at the men value of violence index and rainfall variation.

7. Conclusions

This paper proposes a measure of resilience capacity at household level and provides empirical evidence on how the estimated resilience index contributes to understand food security issues in Tanzania and Uganda. The main results of the analysis are the following:

a) adaptive capacity is the most relevant attribute contributing to household resilience and education is one of the most relevant component of adaptive capacity in both countries;
b) the resilience index positively influences future household food security outcomes (proxied by percapita food caloric intake and the Shannon dietary diversity index),

decreases the probability of suffering a food security loss should a shock occur and speeds up the recovery after the loss occurrence, and

c) shocks have a negative effect on food security and resilience contributes to reduce the negative impacts of these shocks, though this is not proven for self-reported and idiosyncratic shocks.

Besides the specific results highlighted above, the resilience measuring approach proposed in this paper can be used to guide policy interventions. First, it helps in identifying the most relevant characteristics that contribute to build resilience capacity at household level. For instance, in Tanzania and Uganda education clearly results to be the most useful tool to increase household resilience. Second, the proposed approach can be used to reduce the multi-dimensionality of the resilience capacity into an index suitable for targeting purposes. In doing this, the least resilience households can be identified and specific interventions to increase their own resilience capacity can be implemented thus reducing the household vulnerability to food insecurity.

The results of this paper are encouraging in operationalizing the concept of resilience as a policy objective. However, the way to fully operationalize this concept is still long and further evidence needs to be provided before using it. For instance, this paper did not analyze the different mechanisms through which the household resilience capacity affects household food security. In other words, the empirical tests presented in this paper confirm the existence of a positive association between the RCI and household food security without investigating conduit mechanism to food security attainments.

Additional avenues for further research are largely conditional upon the availability of good data. For instance, the analysis should be extended to other African countries, surveyed by the LSMS-ISA project to ensure the comparability of the datasets. An expanded sample of countries can provide more robust evidence, confirming or confuting the results presented here. Furthermore, using longer time series of household surveys, as soon as they will be available, may prove useful in deepen the analysis especially on the role of shocks and the relationships between household resilience capacity and shocks on food security attainments.

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Annex

Table 9 Summary statistics: Uganda and Tanzania (pooled samples, 3 rounds)

	Uganda				Tanzania			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Pc Food expenditure (US dollars)	7.189	9.053	0	145.366	20.116	12.377	0.43	90.029
(log) Food expenditure	1.388	1.249	-3.988	4.979	2.816	0.631	-0.844	4.5
Shannon dietary diversity	1.144	0.452	0	1.993	1.292	0.335	0	2.084
FCS	60.994	20.390	0	126	42.789	17.887	0	110.833
Pc caloric intake	1940.202	845.030	19.471	5191.518	2455.699	1589.443	0	9923.642
Resilience index (estimated)	0.014	0.331	-0.819	3.677	0	0.462	-1.152	1.975
Infrastructural index	-0.105	0.937	-0.898	4.567	0.203	0.304	-0.038	1.024
Distanced to school	22.793	14.457	0	90	0.515	1.801	0	33.333
Distance to market	35.766	35.216	0	300	0.419	2.334	0	100
Agricultural index	0.016	0.768	-0.858	18.427	-0.102	0.95	-0.733	14
Wealth index	0.04	1.263	-1.726	11.269	0.075	0.639	-0.923	2.297
Land own	1.44	5.458	0	330.264	1.296	2.04	0	34.803
Tropical Livestock Unit (TLU)	1.318	8.323	0	575.26	1.366	4.248	0	66.4
Participation index	0.28	0.376	-0.593	1.385	0.17	0.421	-0.463	1.299
Average education	4.715	3.665	0	17	5.202	3.349	0	17
Dependency ratio	0.983	0.955	0	9	0.526	0.237	0	1
Private transfers (US dollars)	1.525	5.815	0	123.607	0.728	1.466	0	12.157
Other transfers (US dollars)	0.39	2.656	0	49.333	0.028	0.284	0	20.055
Female HH head	0.314	0.464	0	1	0.247	0.431	0	1
Age of HH head	47.683	14.943	0	100	48.23	15.224	17	107
HH size	5.539	2.847	1	23	5.579	3.008	1	55
Squared HH size	38.784	40.381	1	529	40.179	68.261	1	3025
HH engaged in agriculture	0.839	0.367	0	1	0.766	0.423	0	1
Drought / Floods	0.224	0.417	0	1	0.367	0.482	0	1
Crop pest and disease	0.168	0.374	0	1	0.034	0.180	0	1
Fall in price of crops	0.178	0.383	0	1	0.028	0.165	0	1
High cost of inputs	0.182	0.386	0	1				
Livestock shock	0.156	0.363	0	1				
Rise price of food	0.522	0.500	0	1	0.317	0.466	0	1
Business failure	0.041	0.199	0	1				
Loss of employment	0.020	0.140	0	1	0.107	0.309	0	1
Water shortage	0.254	0.435	0	1				
Illness	0.074	0.262	0	1				
Death HH members	0.110	0.313	0	1				
Deaths others	0.324	0.468	0	1				
Break household	0.046	0.210	0	1				
Jail	0.005	0.071	0	1				
Fire	0.016	0.126	0	1	0.010	0.101	0	1
Robbery	0.076	0.265	0	1	0.051	0.220	0	1

Dwellimg demage	0.008	0.087	0	1				
Conflict					0.017	0.130	0	1
Other	0.040	0.195	0	1				
Rainfall variation	0.229	0.027	0.170	0.311	0.245	0.082	0.125	0.536
Violence index	6.962	15.170	0.000	74.701	1.809	4.538	0.000	27.640
Obs.	5,829				8,604			

Note: all the monetary values are expressed as monthly and per capita.

Table 12 BE models of covariate shocks on percapita food caloric intake and dietary diversity

	Tanzania		Uganda	
	(1)	(2)	(3)	(4)
	Percapita caloric intake	Dietary diversity	Percapita caloric intake	Dietary diversity
RCI	45.43***	0.0214***	98.15***	0.0414***
	(0.943)	(0.000297)	(4.148)	(0.00121)
Violence index	-3.818	-0.00338	-11.59***	-0.00516***
	(6.810)	(0.00220)	(2.464)	(0.000591)
Rainfall variation	-627.0**	0.0149	1,880*	0.265
	(292.2)	(0.0805)	(988.2)	(0.199)
Female HH head	9.013	0.00846	72.73	0.0386***
	(20.62)	(0.00635)	(47.81)	(0.00896)
Age of HH head	2.173***	-0.000245	7.994***	0.000527*
	(0.532)	(0.000195)	(1.767)	(0.000303)
HH size	-41.04*	0.0142***	-42.82*	0.0876***
	(22.25)	(0.00275)	(22.99)	(0.00655)
Squared HH size	1.139	-0.000159	0.00840	-0.00402***
	(1.554)	(0.000157)	(1.815)	(0.000478)
Rural	131.3***	0.0293***	321.3***	0.0751***
	(23.30)	(0.00577)	(66.97)	(0.0155)
Constant	367.8**	0.484***	-396.4	-0.114**
	(169.9)	(0.0492)	(248.3)	(0.0540)
Observations	8,601	8,601	5,784	5,784
R-squared	0.636	0.747	0.321	0.671
Number of newid	2,867	2,867	1,928	1,928

Regional dummies are included as control; specifically 26 in columns (1) and (2) and 4 in columns (3) and (4).
Robust standard errors at household level in parentheses *** p<0.01, ** p<0.05, * p<0.1