FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

How Specific Resilience Pillars Mitigate the Impact of Drought on Food Security: Evidence from Uganda

Research Paper #3[1]
August 2021

Authors: Nathan Sunday, Rehema Kahunde, Blessing Atwine, Adesoji Adelaja, & Justin Kappiaruparampil

[1] The paper is an outcome of the STAAARS+ fellowship of the Food Security Policy Research, Capacity and Influences (PRCI) program of the USAID Feed the future initiative administered by Michigan State University, Cornell University and the International Food Policy Research Institute. This research is supported by the PRCI.

FOOD SECURITY POLICY RESEARCH, CAPACITY, AND INFLUENCE (PRCI) RESEARCH PAPERS

This Research Paper series is designed to disseminate timely research and policy analytical outputs generated by the USAID-funded Feed the Future Innovation Lab for Food Security Policy Research, Capacity, and Influence (PRCI) and its Associate Awards and Buy-ins. The PRCI project is managed by the Food Security Group (FSG) of the Department of Agricultural, Food, and Resource Economics (AFRE) at Michigan State University (MSU) and implemented by a consortium of three major partners: the International Food Policy Research Institute (IFPRI), Cornell University, the Regional Network of African Policy Research Institutes (ReNAPRI), and the Institute for Statistical, Social, and Economic Research (ISSER) at the University of Ghana. The MSU consortium works with governments, researchers, and private sector stakeholders in Feed the Future focus countries in Africa and Asia to co-create a global program of research and institutional capacity development that will enhance the ability of local policy research organizations to conduct high-quality food security policy research and to influence food security policy more effectively while becoming increasingly self-reliant.

The papers are aimed at researchers, policy makers, donor agencies, educators, and international development practitioners. Selected papers will be translated into other languages.
Copies of all PRCI Research Papers and Policy Briefs are freely downloadable in pdf format from this link. Copies of all PRCI papers and briefs are also submitted to the USAID Development Experience Clearing House (DEC) at this link and to AgEcon Search.

STATEMENT OF SUPPORT

This research is made possible by the generous support of the American people through the United States Agency for International Development (USAID) through funding to the Feed the Future Innovation Lab for Food Security Policy Research, Capacity, and Influence (PRCI) under grant 7200AA19LE000001. The contents are the responsibility of the study authors and do not necessarily reflect the views of USAID or the United States Government.
Published by the Department of Agricultural, Food, and Resource Economics, Michigan State University, Justin S. Morrill Hall of Agriculture, 446 West Circle Dr., Room 202, East Lansing, Michigan 48824, USA.

AUTHORS

Nathan Sunday - University of Michigan, Ann Arbor, USA
Rehema Kahunde - Economic Policy Research Centre (EPRC), Makerere University, Kampala, Uganda.
Blessing Atwine - Economic Policy Research Centre (EPRC), Makerere University, Kampala, Uganda.
Adesoji Adelaja - Michigan State University, USA.
Justin Kappiaruparampil - Michigan State University, USA.

Contact Author:
Nathan Sunday
Email: nsunday@umich.edu/nathansunday8@gmail.com
Phone: +17349345308

AUTHORS' ACKNOWLEDGMENTS

The authors acknowledge the technical support provided by PRCI. The team extends special gratitude to members of STAAARS+ management from both Cornel University and Michigan State University who provided both moral and technical support during the process of writing the paper. In addition, we thank the management of Economic Policy Research Centre (EPRC) for the resources provided to the authors to ensure that this project becomes a success. The team is also grateful for the feedback provided by various researchers, both from EPRC and other institutions that participated in the feedback workshops. We appreciate their time and knowledge that helped us in making our paper better.

ABSTRACT

Uganda continues to be prone to climate shocks especially drought which has adverse impact on food security. This paper studies household resilience capacities with special focus on how different resilience capacities mitigate the impact of drought on food security. The study follows the TANGO framework and two-step factor analysis to construct resilience capacity indexes. It employs a panel data from the Uganda National Panel Surveys (UNPS) undertaken between 2010/11 and 2018/19, spanning five waves. To minimize the bias arising from subjective self-reported drought shock, we introduce an objective measure of drought from the global SPEI database into the UNPS data. We also control for attrition bias by controlling for attrition hazard estimated from the attrition function. Our analysis reveals that households in Uganda exhibit significantly low and nearly static resilience capacities. This implies majority of households in Uganda remain highly susceptible food insecurity in the event of severe drought. The study shows that building resilience capacities is an effective way of protecting households from such devastating situation. In this regard, adaptive capacity is found to be the most effective in mitigating the effect of drought on food security. Transformative capacity and absorptive capacities possess limited mitigating power. Based on significant components from each of the capacities, we recommend investing in early warning systems and wide dissemination of climate related information to enhance preparedness adaptation, encouraging and supporting formation and sustainability of informal institutions at local levels, enhancing access to communal resources, improved infrastructure and agriculture extension services by the most vulnerable groups.

Key words: Drought, resilience capacities, food security,
JEL Codes: D10, I32, Q18

EXECUTIVE SUMMARY

Globally, approximately 55 million people are affected by drought annually. In Africa, drought affects an average of 14 percent of the people living in drylands in any given year. In Uganda, drought has been identified as the most challenging climate hazard with devastating effects on food security given that almost 70 percent of Ugandans rely heavily on farm production. The recurrence of drought threatens food security across different countries through its negative impact on agricultural production and this is likely to be greater for households with weak resilience capacities.

Therefore, building resilience is critical for preparedness, mitigation, recovery and adaptation to drought. To effectively moderate the adverse effects of drought, deeper understanding of the roles of resilience capacities and related factors in mitigating shocks are needed. There is a growing body of literature on resilience and food security, however analytical gaps still exist especially given the diversity in resilience measurement approaches. Existing studies follow a static approach that does not account for evolution of resilience overtime and do not assess the role played by the different resilience capacities-Adaptive, Absorptive and Transformative in mitigating the impact of drought on food security.

This study therefore closes the gap in literature by analyzing resilience of Ugandan households to food security in the event of drought in two major ways. First, unlike previous studies, this study makes use of nationally representative household panel data (Uganda National Panel Surveys) and global Standardized Precipitation Evapotranspiration index (SPEI) data to account for the temporal dynamics of resilience. Secondly, this study provides empirical evidence on the effectiveness of not just the general resilience capacity index, but also the different resilience capacities in mitigating the impact of drought on food security.

The study follows the TANGO framework which uses factor analysis to construct resilience capacity index (RCI) based on three types of resilience capacities. This approach allows for construction of RCI without incorporating the outcome variable-food security, thus allowing RCI to be used as an explanatory variable.

Findings of this study reveals that households in Uganda exhibit significantly low and nearly static resilience capacities. This implies that majority of households in Uganda remain highly susceptible to food insecurity in the event of severe drought. Our analysis also shows that indeed drought undermines food security by reducing both the amount of food consumed and the number of times a household eats in a day. However, the impact reduces with drought duration implying that households and humanitarian agencies are reactionary in nature triggering resilience mechanisms after the shock has happened as opposed to building resilience.

Results further show that increase in resilience capacity index enhances household food security through both per capita food consumption and number of meals per day. This implies that as a household becomes more resilient, it's able to increase both quantity of food consumed and the number of times they eat in a day. Regression analysis based on the three resilience capacities reveals that absorptive significantly enhances per capita food consumption and the number of times households eat. Adaptive and transformative capacities are only effective in enhancing per capita food consumption. Nonetheless, results suggest that increase in each of these capacities results in more than proportionate increase in per capita food consumption.

Based on this discussion, there is need to invest in improving household resilience through investing in early warning systems to enhance access to climate related information to the vulnerable groups to ensure their preparedness and adaptation. It is also important to rejuvenate and support informal institutions such as women's groups, saving groups, mutual help groups, youth groups, agriculture cooperatives and other community-based associations.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

Acronym	Definition
CBO	Community Based Organisation
DRF	Disaster Risk Finance
FAO	Food and Agriculture Organisation
IPCC	Inter-Governmental Panel on Climate Change
LIPW	Labour Intensive Public Works
LSMS	Living Standards Measurement Survey
NGO	Non-Governmental Organisation
NUSAF	Northern Uganda Social Action Fund
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
RCI	Resilience Capacity Index
RIMA	Resilience Index Measurement Analysis
RM-TWG	Resilience Measurement Technical Working Group
ROSCA	Rotating Saving and Credit Association
SACCO	Savings and Credit Cooperative Organisation
SAGE	Social Assistance Grants for Empowerment
SPEI	Standardised Precipitation Evapotranspiration Index
SSA	Sub-Saharan Africa
UNFPA	United Nation Population Fund
UNPS	Uganda National Panel Surveys
USAID	United States Agency for International Development
USD	United States Dollar
VSLA	Village Savings and Lending Association
WHO	World Health Organisation

INTRODUCTION AND MOTIVATION

Over the years, drought has been a growing concern globally due to its debilitating direct and indirect effects on livelihoods (Shiferaw et al, 2014). Globally, drought has affected more people, compared to any other natural hazard and its adverse effects have more than doubled in the last 40 years (FAO, 2020)[2]. Approximately 55 million people globally are affected by drought annually (WHO, 2020)[3]. In Africa, drought affects an average of 14 percent of the people living in drylands in any given year (Raffaello & Michael, 2016)[4]. The situation is likely to be exacerbated by ongoing climate change (in the form of increased frequency and intensity of extreme weather conditions, such as high temperatures) which is likely to intensify droughts in many parts of the world (Nsubuga and Rautenbanch, 2018).

The recurrence of drought particularly threatens food security across different countries (FAO, 2011) through its negative impact on agricultural production (Majaliwa et al., 2010; Mbolanyi et al., 2017) and farm household incomes (Shiferaw et al., 2014). More succinctly, drought results in lower yields in both crop and livestock production, and increased livestock deaths (FAO, 2011; Kogan et al, 2019), thus affecting food availability, access, and utilization (FAO, 2011). For instance, between 2005 and 2015, drought caused 30 percent of agricultural loss in developing countries, which amounted to over USD 29 billion (FAO, 2017).

In Uganda, drought has been identified as the most challenging climate hazard with devastating effects on food security given that almost 70 percent of Ugandans rely heavily on farm production (FAO et al., 2015). For instance, in 2017 when the country reportedly experienced severe drought, about 10.9 million people experienced food insecurity, with 1.6 million at the brink of starvation (UNFPA Uganda, 2019). The adverse impact of drought on food security is likely to be greater for households with weak resilience capacities (Filho and Mannke, 2012, Shiferaw et al, 2014). In this regard, building resilience is critical for preparedness, mitigation, recovery and adaptation to drought.

Resilience is also a critical analytical and policy concept because it allows the understanding of household vulnerabilities and the strategies they adopt to manage shocks (D'Errico et al, 2018). To effectively moderate the adverse effects of drought, much deeper scientific evidence on the unmitigated impacts of drought and the roles of resilience capacities and related factors in mitigating shocks are needed. This paper therefore addresses the question "**what are the most important resilience pillars in mitigating the impact of drought on food security in Uganda?**"

Whereas there is a growing body of literature on resilience and food security, analytical gaps still exist especially given the diversity in resilience measurement approaches. For instance, the seminal

---

[2] http://www.fao.org/land-water/water/drought/droughtandag/en/
[3] https://www.who.int/health-topics/drought#
[4] Drylands make up about 43 percent of the continent's land surface, account for about 75 percent of the area used for agriculture, and are home to about 50 percent of the population (Raffaello & Michael, 2016

work by Alinovi et al. (2008 and 2010) heavily relied on proxies such as index of coping mechanisms rather than the actual shocks due to data limitations (d'Errico et al, 2018). Most of the subsequent work that builds on Alinovi et al's ideas of estimating resilience as a latent variable (such as Vaitla et al, 2012; Smith et al, 2014; FAO, 2015 and 2016a; d'Errico and Di Guiseppe 2016, among others), follow a static approach largely due to data limitations as most of them rely on cross-sectional data. While D'Errico et al (2018) attempted to address the shortcomings of static analytical framework in the context of Uganda and Tanzania, their study does not account for evolution of resilience over time since resilience construction is based on one wave. More so, this study only assesses the effectiveness of overall resilience capacity index which masks the differences in the mitigating role of different resilience capacities. Other studies on drought and food security in Uganda (such as Twongyirwe et al, 2019) are limited in geographical scope (only focused on one district) and also did not factor in the role of resilience capacities.

This study therefore contributes to literature by analyzing resilience of Ugandan households to food security in the event of drought in a number of ways. First, unlike the aforementioned study, this paper makes use of a rich, nationally representative household panel data (Uganda National Panel Surveys) spanning five waves (2010/11, 2011/12, 2013/14, 2015/16, and 2018/19). In so doing, the study accounts for the temporal dynamics of resilience by measuring resilience capacity index in each wave with a view that household's resilience capacity is not static, and as it changes, its moderating role on the impact of drought also changes. Second, this study provides empirical evidence on the effectiveness of not just the general resilience capacity index, but also the different resilience capacities in mitigating the impact of drought on food security. In so doing, our study makes a practical contribution regarding prioritisation and focusing resources on critical aspects of resilience building.

Evidence provided by this study is particularly important in guiding interventions aimed at mitigating the potential losses from drought. This is because prior interventions such as Disaster Risk Finance (DRF)[5] and Social Assistance Grants for Empowerment (SAGE) have been ad-hoc and less effective due to limited empirical evidence (Maher, 2017)[6]. Furthermore, the study provides knowledge-based basis for the need to invest in adaptation to drought, especially for a country where food security is increasingly becoming an issue of concern.

The rest of the paper is organized as follows. Section 2 explores the existing literature on drought, the resilience concept, resilience measurement and food security. Section 3 advances a conceptual framework that links drought shocks to food security while explaining the roles of resilience factors. Section 4 provides information on the empirical strategy and models, description of the data, the construction and discussion of the resilience capacity indexes. Section 5 contains the results

---

[5] Disaster risk finance (DRF) is a component of the governements' Third Northern Uganda Social Action Fund (NUSAF III) project, that seeks to build the resilience against shocks mainly drought of poor and vulnerable households in northern Uganda by providing income support in the form of labor-intensive public works (LIPW).

[6] https://blogs.worldbank.org/psd/building-resilience-against-drought-case-uganda.

regarding estimated mitigating effects of resilience on the impact of drought on food security. Section 6 provides a summary, conclusions and policy recommendations.

REVIEW OF LITERATURE]

This section highlights existing knowledge regarding drought shocks, food security, the resilience concept, and the linkages between all three. More specifically, we highlight the literature on impact of drought on food security and the mitigating role of resilience. In this section, we further emphasize our identified research gap and provide a basis for developing an appropriate conceptual framework and methodology.

2.1 Drought and food security

Drought[7] remains a major source of food risk and income, especially for the rural households in developing countries (FAO, 2017). In Africa, drought has been found to affect three times more people than all other natural disasters combined (Dinkelman 2017). Indeed, drought poses a huge threat to food security[8] by undermining agricultural production and household income (Shiferaw et al., 2014; Twongyirwe et al., 2019). As such, the rising malnutrition and famine in many SSA countries, Uganda inclusive has been largely attributed to drought (Shiferaw et al., 2014; Watuleke, 2015; Funk et al., 2014 and d'Erico et al., 2018).

2.2 The concept of resilience and its measurement

Resilience is a multifaceted concept, with different definitions offered by various disciplines, agencies and scholars (d'Errico et al 2018) such as FAO, USAID and OECD. As such, the definition and measurement of resilience are widely contested. It is however worth noting that the most dominant definition of resilience is that by the Resilience Measurement Technical working group (RM-TWG, 2016) which defines resilience as "the capacity that ensures adverse stressors and shocks do not have long-lasting adverse development consequences".

This definition alludes to the absorptive[9] , adaptive[10] and transformative[11] capacities of victims of a shock/stressor which result into persistence, adjustments and transformational responses, respectively (Aldrich and Meyer, 2015; Jones and Tanner, 2015). These capacities are the core components of resilience that need to be considered in a household resilience conceptual and analytical framework (Bene et al, 2012; Frankenberger et al 2013; Weldegebriel & Amphune 2017; Asmamaw et al, 2019).

[7] The Inter-Governmental Panel Climate Change (IPCC) (2012) defined drought as "a period of abnormally dry weather, long enough to cause a serious hydrological imbalance"
[8] United Nations refers to food security as "People having at all times, physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (Guymard et al., 2012).
[9] Absorptive capacity in this sense refers to the ability to minimize exposure to shocks and stresses (ex-ante) where possible and to recover quickly when exposed (ex post)
[10] Adaptive capacity refers to the ability to adjust to changes, moderate damage and to take opportunities
[11] Transformative capacity refers to the ability to create a new system to make conditions attainable

In constructing the above resilience capacities and the overall resilience capacity index, researchers have adopted different frameworks and methodologies, which can be grouped into subjective and objective approaches. While the subjective approach is based on an individual's self-evaluation of his/her household's capabilities in responding to shocks (Choptiany et al, 2015; Jones et al, 2018), the objective approach (used by most scholars) is mainly based on observable key socioeconomic indicators and other types of capital that support livelihoods (Bahadur et al., 2015; Jones & Samman, 2016). In the later approach, resilience is measured as a latent/unobservable variable based on observable indicators (Alinovi et al., 2008; Smith & Frankenberger, 2018; d'Errico et al, 2018).

For instance, using a two-stage factor analysis, Alinovi et al. (2008 and 2010) estimated resilience as an unobservable variable using observable indicators such as social safety nets, access to public services, assets, income and food access, adaptive capacity and stability. In the same vein, Smith et al (2014) estimated community resilience in Ethiopia along three capacities (absorptive, adaptive and transformative) using Principal Component Analysis (PCA).

Building on Alinovi et al's. (2008 and 2010) seminal idea that resilience is a latent variable, the FAO developed an overarching framework for estimating resilience known as Resilience Index

Measurement Analysis (RIMA) framework. This framework is based on four pillars (access to basic services, assets, social safety nets and adaptive capacity) where Resilience Capacity Index (RCI) was estimated through a two-stage procedure using a structural equation model (FAO, 2016a). Using the FAO's RIMA framework, TANGO international developed a significantly modified version of the same that focuses on household and community level capacities—absorptive, adaptive and transformative which the paper seeks to analyse—see section 4.3 for more details (Upton et al., 2020).

2.3. Mitigating role of resilience on the impact of drought on food security

The moderating role of resilience may vary depending on the resilience capacities possessed by a household. For instance, Frankenberger & Smith (2015) shows that absorptive capacity poses stronger mitigation power compared to adaptive and transformative as far as the impact of drought on food security in Ethiopia is concerned. Similarly, scholars such as Bahadur et al (2015) emphasize the role of absorptive and adaptive capacities while transformative was regarded as a reshaping approach that enables a household to adapt, anticipate and absorb shocks like drought.

Cognizant of the role played by the household resilience, the government of Uganda and other stakeholders have undertaken initiatives such as Social Assistance Grants for Empowerment (SAGE) aimed at developing resilience capacities of vulnerable households (Ulrich & Slater, 2017). However, these interventions do not specifically target the impacts of drought on households' food security and most of such programmes have been generally reactive in nature and poorly coordinated (Duguma et al., 2017; Gerber & Mirzabaev, 2017).

CONCEPTUAL AND THEORETICAL FRAMEWORKS

This section presents the conceptual and theoretical frameworks linking drought, resilience and food security. More specifically, the conceptual framework highlights the pathways through which drought affects food security while demonstrating the role of resilience in mitigating the impact of drought on food security. The theoretical framework links the conceptual framework to the empirical model, thereby forming the basis for our empirical strategy.

3.1 Conceptual framework

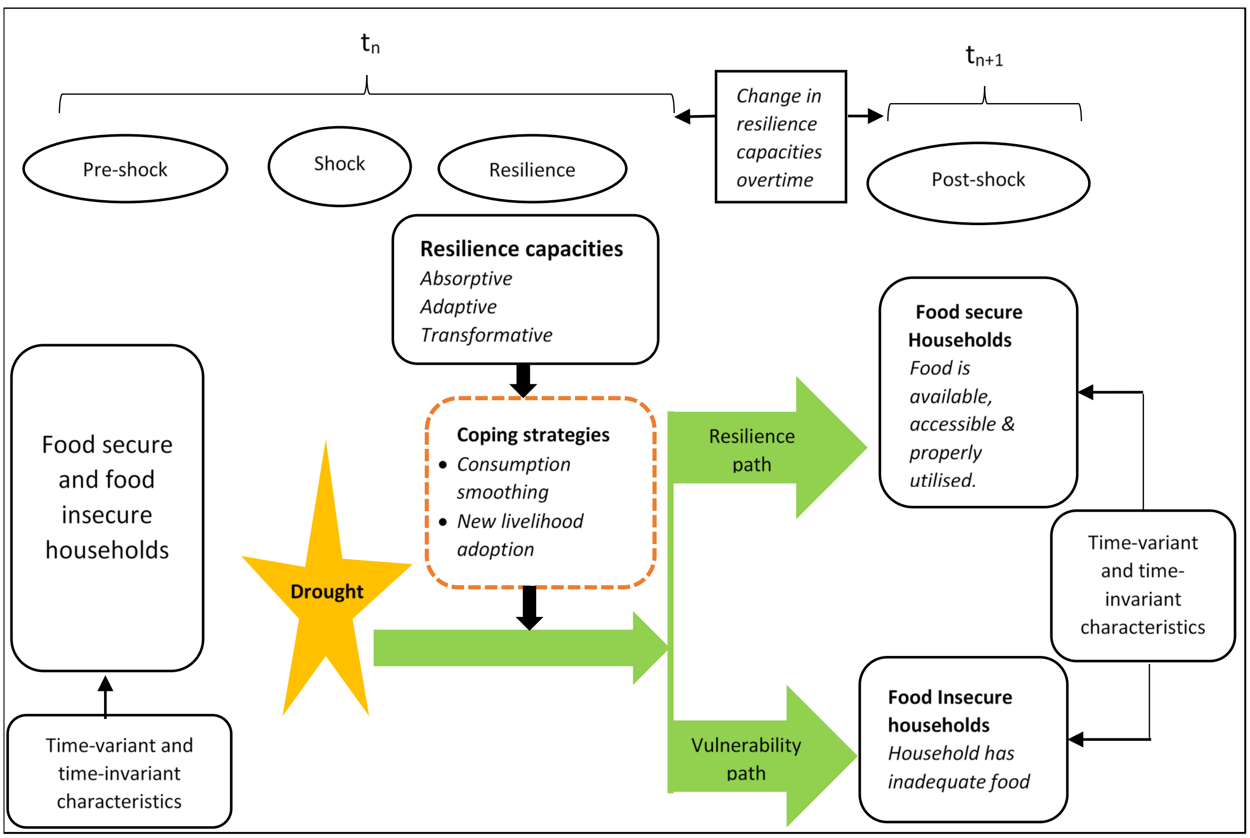
Based on the literature surveyed in the previous section, this study conceptualizes resilience as a latent variable (Alinovi et al., 2008 and 2010; FAO, 2016a; FAO, 2016b; d'Errico et al, 2018) which moderates the impact of drought on household food security. In line with studies such as Aldrich & Meyer (2015); Jones & Tanner (2015), and Asmamaw et al (2019), we categorize resilience into three capacities; absorptive, adaptive, and transformative, which enables us to examine the effectiveness of each resilience capacity in mitigating the impact of drought on food security. In the study, we regard absorptive, adaptive and transformative capacities as the ability of households to resist, adapt, and transform, respectively, against the negative impacts of drought.

By considering the three resilience capacities, the conceptual framework integrates ex-ante preparedness and prevention plus the response and recovery activities (ex-post) into resilience analysis. (Ansah et al, 2019). The conceptual framework for this paper (Figure 1) also recognizes resilience as an intrinsically dynamic concept. As such, it allows analysis of the temporal dynamics of resilience and the dynamic role of different resilience pillars in mitigating the impact of drought on food security.

The conceptual framework shows the pathways from drought to food security while accounting for the mitigating role of household resilience capacities. Figure 1 specifically shows that when drought occurs, household resilience mechanisms are activated which induce coping strategies for consumption smoothing and adoption of new livelihoods in the bid to counter its impact on food security. In the initial stage, a household is either food secure or insure depending on a number of time variant and time invariant household characteristics. When drought sets in, it is presumed to affect the livelihood strategies which transmits to food availability, accessibility, and utilization. However, the extent to which drought affects food security depends on the household's ability to absorb, adapt and transform livelihood. Conceptually, there are two possible pathways: the resilience pathway and the vulnerability pathway. A household with high capacity to absorb drought, adapt and transform livelihood by adopting coping strategies follows the resilience pathway and bounces back to the normal state or even better. On the other hand, a household with weak capacity to absorb drought, adapt and transform livelihood follows the vulnerability pathway and ends up in a dire situation of food insecurity in the subsequent period.   Note that between the two extremes, there are varying degrees of resilience. This also implies varying bounce-back abilities and timeframes.

Notably, resilience is a dynamic concept that is subject to change between period t and $t + n$. On one hand, the coping strategies owing to the shock in period t such as selling assets, draining income sources, etc., may limit future capacity to react to shocks (FAO, 2016b). On the other hand, positive changes in social-economic and institutional (such as access to basic social service) factors boosts households' capacity to respond to drought. Therefore, the net change in resilience capacity between t and $t + n$ for a household that experienced drought in period t depends on which of the two effects outweighs the other, assuming other factors constant. For a household that did not experience drought in period t, the change in resilience overtime depends on positive changes in social-economic and institutional factors (such as access to basic social services), keeping other factors constant.

Figure 1. Conceptual framework linking drought, household resilience and food security



Source: Author's own construction (2020) based on the ideas of FAO (2016b) and Frankenberger et al., (2012)

3.2 Theoretical framework

To actualize the conceptual framework illustrated in Figure 1, we develop a theoretical model linking drought and food security while accounting for the mitigating role of household resilience. We adopt and modify an agricultural household model developed by Singh, Squire and Strauss in 1986 to account for drought as a shock and resilience as a mitigating capacity. More succinctly, we follow a utility maximizing approach to explain how a household's exposure to drought can affect its food security and then show how resilience dampens the impact of drought on food security.

Following Faridi & Wadood (2010), we assume that a household is both a producer and a consumer and can separate production decisions and consumption preferences. Furthermore, household consumption is comprised of own-produced food (F_O) and purchased food items (F_m). Therefore, the utility function of a representative household is given by;

$$U=f(F_O, F_m, X_m, l, Z) \tag{1}$$

where; X_m is a vector of non-food items purchased by a household, l denotes the amount of time spent on leisure and Z represents other household level preferences and characteristics which may influence its utility. The utility function in equation (1) is assumed to be twice differentiable, quasi-concave and strictly increasing in its arguments.

In maximizing its utility, the household is faced with production, income and time constraints (Faridi & Wadood, 2010; George et al, 2020). Given its high dependence on rain-fed agriculture, agricultural production in Uganda is particularly vulnerable to drought (Kansiime et al, 2013). Therefore, drought (D) is introduced into the production function as an exogenous shock determining agriculture output. Thus the production, time, and income constraints are given by:

$$Q = f(L, K, A) - \lambda_d D \tag{2}$$

$$T = L_f + l \tag{3}$$

$$P_o(Q - F_o) + N - P_{m1}F_m - P_{m2}X_m - w(L - L_f) = 0 \tag{4}$$

The production function in equation (2) is assumed to be twice-differentiable, increasing in inputs and strictly convex. L, K and A are the labor, capital and land inputs used in the production process, respectively. Following Faridi & Wadood (2010) and George et al (2020), we assume other inputs (such as fertiliser, seeds, and pesticides) are used in fixed proportions with land and therefore only control for land to simplify the model. Furthermore, capital and land are assumed to be fixed. In the production function, drought shock (D) is a variable capturing either incidence (dummy variable taking "1" if the household experienced drought, "0" otherwise) or duration of drought. Therefore, λ_d is a positive scalar measuring the magnitude by which drought reduces agricultural output. For simplicity we treat drought as an exogenous shock which does not interact with other factors. In equation (3), T is the total time available to the household to allocate between work (L_f)

and leisure (l). P_o is the per unit value of food produced by the households, P_{m1} is the price of food items purchased from the market and consumed by the household, P_{m2} is the price of non-food items purchased by the household, and w is the prevailing wage rate that the household pays for hired labour. Combining the income and time constraints in equations (3) to (4), we obtain the following expression;

$$P_oQ + N + wT - wL = P_oF_o + P_{m1}F_m + P_{m2}X_m + wl \tag{5}$$

The left-hand side of equation (5) represents household income, which includes income from agricultural production (P_oQ), non-farm activities (N), the value of time endowment (wT) less the value of labor used on the farm (wL). The right-hand represents household expenditure on food (the value of self-produced and purchased foods), non-food items, and leisure.

Given the "separability" assumption, the household solves the production and consumption problems separately. On the production side, optimal input demand (L^*) and output (Q_i^*) are obtained from a profit maximization problem that is expressed in terms of price, wage rate, fixed land and capital:

$$L^* = L^*(P_0, w, A, K) \tag{6}$$

$$Q_i^* = f^*(P_0, w, A, K) - \lambda_d D \tag{7}$$

Therefore, from the expression on the left-hand side of equation (5), the household's full income (Y^*) under profit maximization is given in terms of price, wage rate, fixed land, fixed capital, non-farm income and drought shock, $Y^*(P_0, w, A, K, N, D)$, as explicitly shown below:

$$Y^* = P_0[f^*(P_0, w, A, K) - \lambda_d D] + wT - wL^*(P_0, w, A, K) + N \tag{8}$$

Turning to consumption preferences, the household maximizes the utility function in equation (1) subject to the budget constraint in equation (5), given the optimum income(Y^*). More specifically, the household utility maximisation problem is given by:

$$\max_{F_0, F_m, X_m, l} U(F_O, F_m, X_m, l, Z) \tag{9}$$

$$subject\ to$$

$$(Y^*(P_0, w, A, K, N, D) = P_oF_o + P_{m1}F_m + P_{m2}X_m + wl) \tag{10}$$

Solving equation (9) and (10), equilibrium consumption demand for food (F_k^*) (whether from own production or purchased) is given in terms of prices, wage rate and income.

$$F_k^* = F_k\left[P_o, P_{m1}, P_{m2,} w, Y^*(P_0, w, A, K, N, D)\right], \tag{11}$$

As earlier mentioned, food security entails four dimensions: availability, access, stability and utilization. However, for simplicity, we restrict the derivations to food access and availability. Whereas access reflects the demand side, availability reflects the supply side of food security (Barrett et al, 2013). Therefore, food access is largely represented by equation (11) while food availability is given by the aggregate food production of households in the country $(Q_T = \sum_{i=1}^{n} Q_i^*)$. Food Utilization reflects concerns about whether individuals and households make good use of the food to which they have access (Barrett et al, 2013). Therefore, availability and access precede utilization. Accordingly, food security (FS) can be expressed as shown in equation (12).

$$FS = FS(F_k^*, Q_T) \tag{12}$$

To obtain the impact of drought on food security, we take the first order partial derivative of equation (11) with respect to drought (D) as shown in equation (13).

$$\frac{\partial FS}{\partial D} = \frac{\partial FS}{\partial F_k^*}\frac{\partial F_k^*}{\partial D} + \frac{\partial FS}{\partial Q_T}\frac{\partial Q_T}{\partial D} \tag{13}$$

From equation (8) and (11), $\frac{\partial F_k^*}{\partial D} = -P_o \lambda_d \frac{\partial F_k^*}{\partial Y^*}$. From equation (7), $\frac{\partial Q_i^*}{\partial D} = -\lambda_d$. Making these substitutions in equation (13) we show that drought has both direct and indirect effects on food security. The direct effects of drought manifest through reduction in agriculture production thus limiting food availability. The indirect effects manifest through reduction in household income from the sale of farm produce, thus undermining food access and consequently utilization. Equation (14) illustrates the impact of drought on food security:

$$\frac{\partial FS}{\partial D} = \left(-P_o \lambda_d \frac{\partial F_k^*}{\partial Y^*}\right)\frac{\partial FS}{\partial F_k^*} - \lambda_d \frac{\partial FS}{\partial Q_T}, \tag{14}$$

where $(P_o \lambda_d)$ is the loss in agriculture income as a result of drought while λ_d is the loss in agriculture output as a result of drought.

However, as highlighted in the literature section, the impact of drought on food security can be moderated by household's resilience capacity as households with weak resilience capacities are more susceptible to the impacts of drought compared to those with strong resilience capacities (Shiferaw et al, 2014; Twongyirwe et al, 2019). To incorporate this concept, we utilize the approach used by Adelaja et al (2020) in capturing the mitigating impact of resilience. The idea is that in the presence of resilience, the impact of drought is not fully transmitted to food security. Note that we introduce resilience at this point rather than earlier in the utility or the production function because resilience is assumed to be relevant only in response to shocks. Furthermore, resilience is a capacity built exogenously to the production process but could be related to the production function. Assuming R is a normalized resilience capacity index ranging from 0 to 1, where 0 represents completely vulnerable households with no protection against drought while 1 represents absolute resilience where the household is 100 percent protected from the adverse effects of drought, equation (14) can be modified to incorporate the mitigating impact of resilience as shown below;

$$\frac{\partial FS}{\partial D} = (R-1)\left(P_o \lambda_d \frac{\partial F_k^*}{\partial Y^*}\right)\frac{\partial FS}{\partial F_k^*} + (R-1)\lambda_d \frac{\partial FS}{\partial Q_T}, \tag{15},$$

Note;

From equation (15), $\frac{\partial F_k^*}{\partial Y^*}$ is the marginal impact of income on food demand, $\frac{\partial FS}{\partial F_k^*}$ is the marginal impact of food access on food security, while $\frac{\partial FS}{\partial Q_T}$ is the marginal impact of aggregate food production on food security. Denoting these marginal impacts by ϕ, ψ, and φ respectively, and making the necessary substitutions, equation (15) can be reduced to the form in equation (16).

$$\frac{\partial FS}{\partial D} = -\Theta + \Theta R, \qquad (16)$$

where $\Theta = \lambda_d(P_o\phi\psi + \varphi)$. Equation (16) therefore suggests that households that have absolute resilience $(R = 1)$ are totally insulated from the adverse effects of drought on food security. On the other hand, households that have zero resilience $(R = 0)$ are exposed to the adverse effects of drought on food security and therefore bear the full effect of the shock. However, absolute resilience is elusive in reality. Therefore, the expression on the right-hand side of equation (16) results in a negative value whose absolute magnitude reduces with increase in resilience capacity index. Following Asmamaw et al's (2019), this study also hypotheses that the rate at which the magnitude of the right-hand side expression reduces varies depending on the different resilience pillars (absorptive, adaptive, and transformative). Therefore, we test these assertions using the empirical strategy described in the subsequent section.

EMPIRICAL STRATEGY, DATA AND CONSTRUCTION OF RESILIENCE CAPACITY INDEX

In this section, we describe the empirical strategy adopted to examine the relationships between drought and food security while accounting for the mitigating role of resilience capacities. We also discuss the dataset used in the analysis. Furthermore, we provide details on the methods used in constructing the resilience capacity indexes and the indicators of both the resilience capacities (absorptive, adaptive and transformative) and household food security.

4.1 Empirical strategy

To practically demonstrate the relationships presented in equation (16), we setup a simple empirical strategy showing how resilience capacity moderates the impact of drought on food security. In general, two models are specified. First, we estimate the mitigating impact of overall resilience capacity index, and then introduce the three resilience capacities. The general specifications of the empirical models are shown in equations (17) and (18).

$$FS_{it} = \alpha + \gamma RCI_{it} + \beta^{'} X_{it} + \theta D_{it} + \Phi(RCI_{it} * D_{it}) + \mu_i + e_{it}, \tag{17}$$

$$FS_{it} = \alpha + \gamma^{'} RC_{it} + \beta^{'} X_{it} + \theta D_{it} + \Phi^{'}(RC_{it} * D_{it}) + \mu_i + e_{it}, \tag{18}$$

where FS is food security, measured by the indicators discussed below. RCI is the overall Resilience Capacity Index, RC is a vector of the three resilience capacities and D is drought shock. X is a vector of household demographics (age of household head, gender of household head, marital status of household head, family-size) and location variables (urban/rural and regions).

The interaction between RCI and D enables us to examine the extent to which resilience mitigates the impact of drought on food security. The interaction between resilience capacities (equation 17) and drought enables us to examine which capacities have the highest mitigating effect on the impact of drought on household food security. The inclusion of interactive terms in the model indicates that the impact of drought on food security is dependent upon household's resilience capacity and that households are affected differently depending on their level of resilience. Based on equations (17) and (18), the marginal impact of drought is given by equation (19) and (20);

$$\frac{\partial FS_{it}}{\partial D_{it}} = \theta + \Phi RCI_{it} \tag{19}$$

$$\frac{\partial FS_{it}}{\partial D_{it}} = \theta + \Phi^{'} RC_{it} \tag{20}$$

From existing literature, θ is expected to be negative since it measures that direct impact of drought on food security. θ is assumed to range between -1 and 0 since households food consumption cannot fall beyond zero. Φ is predicted to be a positive coefficient, neutralising the negative impact of drought on food security. Therefore, similar to the illustration in equation (16), the full impact of drought is only transmitted to food security if resilience capacity index is equal to zero.

In the empirical analysis, two measures of food security have been used; per capita food consumption and number of meals per day. Food security measures were identified based on literature on food security and food security indicators in the UNPS. These are highlighted below;

- *Per capita food consumption:* Similar to d'Erico et al. (2018), we use per capita monthly food consumption, including expenditure on food, the monetary value of own-produced food, and monetary value of food received as gifts. For comparability across waves, the monetary value, is expressed in constant US dollars using the official exchange rate for the years when the data was collected. Given that the relationship between drought and per capita food consumption is likely not to be instantaneous, per capita food consumption is estimated with a one period lead.
- *Number of meals consumed by a household per day:* The household questionnaire captures the number of meals that a household consumes in a day, including breakfast which allows us to examine how drought affects meals consumed by a household and which resilience capacities mitigates the impact of drought.

Given that we have two measures of food security, each of the equations (16 and 17) represents a set of two specific equations based on the different measures of food security. The relationships specified in equations (16) and (17) were examined through linear regression analysis using pooled OLS and fixed effects estimation technique. The major justification for choosing fixed effects over random effects is the need to control for unobserved heterogeneity which is very common with household data. Furthermore, household fixed effects are more likely to be correlated with regressors which might bias estimates in case of random effects. Whereas we are cognizant of potential endogeneity due to non-random exposure to drought by households, the fixed effects estimators control for all time invariant factors which could cause this bias.

Another potential source of bias is attrition, which is likely to be worsened by the sample refresh in 2013 (as highlighted in the data section). To control for attrition bias, we follow the approach adopted by Cheng & Trivedi (2015) which involves specifying and estimating attrition function (probability of dropping out of the sample) from which the attrition hazard (aka inverse mills ratio) is computed. The regression models are then re-estimated while controlling for attrition hazard. Given that attrition hazard is a generated regressor, we use bootstrap standard errors to obtain efficient estimates (Cheng & Trivedi, 2015). The probit specification of the attrition function is given by;

$$Pr[A_{it} = 1] = \Phi[Z'_{it}\gamma] \qquad (21),$$

where; A_{it} is attrition variable which takes the value 1 if the household dropped out of the sample along the way, 0 otherwise. Z_{it} is a vector of covariates which include; age of the household head, gender of the household head, marital status of the household head, household size, education of the household head, and region. Besides the estimation of the attrition function, we also conduct significance tests on different household demographics between households that dropped out of the panel and those that stayed.

4.2 Data

This paper uses five waves (2010/11, 2011/12, 2013/14, 2015/16, 2018/19) of the Uganda

National Panel Survey (UNPS) dataset whose design and implementation were supported by the World Bank Living Standards Measurement Study. These integrated surveys on Agriculture (LSMS-ISA) were implemented by the Uganda Bureau of Statistics (UBoS). Each wave covers a cross section of a nationally representative sample of households surveyed over a twelve-month period (a wave). The initial wave of 2009/10 had 3123 households which were tracked up to 2011/12. However, in 2013, there was a sample refresh which resulted in dropping of one-third of the original sample as new households were brought on board. Therefore, 2082 households transited to 2013/14 and the subsequent waves. Cognizant of the possible attrition bias that is likely to be worsened by the sample refresh, we accord special attention to addressing attrition bias as discussed in the preceding sections.

The UNPS surveys entail household, community and agriculture modules. At the household level, the questionnaire collects information on aspect ranging from household demographics, shocks and coping strategies, labour market participation, asset ownership, welfare & food security, among others. The community-level questionnaire captures the socio-economic characteristics of the community such as access to; markets, health facilities, financial services, schools, roads etc. and Community-Based Organizations (CBOs) and groups. The agricultural questionnaire is administered to agricultural households to gather information on agricultural inputs such as land, agricultural inputs and outputs. The surveys therefore provide sufficient data for analyzing household resilience capacities. Note that we do not use the wave for 2009/10 because the community questionnaire for this wave misses the section on community characteristics, community groups, and communal resources which have been suggested to form part of resilience capacities (Frankenberger & Smith 2015).

In the section on shocks and coping strategies, households were asked whether they experienced listed shocks (drought inclusive) in the twelve months prior to the survey. In the analysis, we use this self-reported incidence of drought alongside an objective measure of drought from global Standardized Precipitation Evapotranspiration Index (SPEI) database. The SPEI database offers long-time, robust information about drought conditions at the global scale, with a 0.5 degrees spatial resolution which allows extraction of country, region, or community specific data. The SPEI is preferred because it takes into account both precipitation and potential evapotranspiration in determining drought (Vicente-Serrano et al., 2010a). In addition, the multi-scalar nature of the SPEI enables identification of different drought types and drought impacts on diverse systems (Vicente-Serrano et al., 2012a). Similar to D'Errico et al, (2018), we generate a dummy variable equal to 1 if

SPEI average is below one standard deviation from long-term average, and 0 otherwise. Nonetheless we also use the index in its continuous form to account for variations in drought severity.

Preliminary analysis shows drought remains a significant shock to Ugandan households. Succinctly, about 22 percent of the households in the pooled sample reported to have experienced drought, with an average duration of 2 months and 6 days (Table 1).[12]

Table 1. Percentage of households that experienced drought and the average duration

	2010/11	2011/12	2013/14	2015/16	2018/19	Pooled Sample
Percentage of households	21.9	13	22.4	17.4	18.0	21.7
Average duration (months)	3.4	3.2	3.1	3.4	3.2	2.2

Source; Author's own construct using data from UNPS 2010/11 to UNPS 2018/19

4.3 Construction of resilience indexes

Resilience is a nascent and multidimensional concept whose measurement and quantification is arguable. Given that resilience capacities are used as explanatory variables and mitigating factors, moderating the impact of drought on food security in this study, it is more pragmatic to adopt the TANGO approach which does not incorporate food security in resilience measurement (D'errico & Smith, 2020).

The TANGO framework uses factor analysis to construct resilience capacity index based on three types of resilience capacity—absorptive capacity, adaptive capacity and transformative capacity (Smith and Frankenberger, 2018; Upton *et al.,* 2020). This approach allows for construction of resilience capacity index without incorporating the outcome variable (food security) (D'errico & Smith, 2020), thus allowing resilience capacity index to be used as an explanatory variable in subsequent analysis of food security.

There is a difference between the TANGO approach and the FAO's RIMA-II framework. The former entirely employs factor analysis (in two steps) using only indicators of resilience capacity. The FAO combines factor analysis with Multiple Indicators Multiple Causes (MIMIC) estimation using both indicators of resilience capacities and food security (D'Errico & Smith, 2020). The TANGO approach analyses resilience along the three capacities (mentioned above) while the FAO approach uses four resilience pillars—access to basic services, assets, social safety nets and adaptive capacity (D'Errico & Smith, 2020). Interestingly, all the four resilience pillars under the FAO framework fall under at least one of the three capacities of TANGO's approach (D'Errico & Smith, 2020).

More so, the TANGO framework provides potential indicators which have already been organised under the three capacities according to the original framework. Nonetheless, both approaches

[12] Assuming a month has 30 days

tantamount to Structural Equations Modeling (SEM) since they rely on multiple observed indicators to measure a single, latent unobserved variable. Markedly, both approaches have been found to yield similar policy implications (D'Errico & Smith 2020) even though they possess several disappointments in out-of-sample predictions which result into false positives and false negatives (Upton et al., 2020).

As already mentioned, we use the TANGO approach to construct resilience capacity index given that it contains all the indicators of FAO's RIMA framework. Specifically, we adopt a two-step factor analysis to construct resilience capacity index for Uganda's households in five waves of Uganda National Household Panel Surveys. In the first step, indexes of three resilience capacities−*absorptive, adaptive, and transformative,* are constructed using factor analysis based on observable variables as suggested by TANGO. In the second step, the overall resilience capacity index is constructed by combining the three indexes of resilience capacities using factor analysis. Note that we analyse resilience for all households, regardless of whether they experienced drought or not.

To calculate an index for the latent variable, factor analysis finds one or more common factors that linearly reconstruct the observed variables by predicting their correlation matrix. It then calculates factor loadings for possibly multiple common factors. These loadings are used to identify which common factor appears to be the one representing the concept being measured. Such identification takes place by examining the signs and magnitudes of the loadings. After identifying a common factor, the loadings are used to calculate the desired index, as a weighted average. The overall resilience capacity index is calculated as follows;

$$RCI = \beta_1 ABC + \beta_2 ADC + \beta_3 TC, \qquad (21),$$

where RCI is resilience capacity index, ABC is absorptive capacity, ADC is adaptive capacity and TC is transformative capacity, βs are factor analysis coefficients estimated using inter-correlations among the three resilience capacity indexes. They are interpreted as weights given to the capacities in the estimation of an overall resilience capacity index, with greater weights given to capacities that correlate more highly with the overall index. The components of each resilience capacities drawn from the TANGO framework are summarized in Table 2.

Table 2. Resilience capacities and their respective components Resilience capacities and components

Resilience capacities and components	Proxy measures for the components
Absorptive capacity	
• Availability of informal safety nets	Availability of groups such as women's groups, saving groups, mutual help groups, youth groups, and religious groups in the community
• Access to remittances	Amount of remittance received monthly per capita
• Asset ownership	Principal component index based on a list of dummy variables assuming a value of 1 or 0, depending on whether or not the household has specific assets
Adaptive capacity	
• Linking social capital	This represents people's ability to form vertical linkages with sources of power and authority outside of their community. Similar to Feed the Future FEEDBACK (2016), we proxy linking capital using the quality of services provided in a households' community (roads, educational facilities, health services, veterinary services, and agricultural services).
• Human capital or Education/training	Years of schooling of the household head
• Livelihood diversification	Principal component index based dummies for different livelihood sources; agriculture, non-agriculture enterprise, wage employment, transfers
• Exposure to information	Principal component index based on a list of dummy variables assuming a value of 1 or 0, depending on whether or not the household owns source of information; radio, TV, mobile telephone
• Availability of financial resources	Principal component index based on a list of dummy variables assuming a value of 1 or 0 depending on whether the community has commercial bank, microfinance institution, or a SACCO
Transformative capacity	
• Availability of/access to formal safety nets	Food assistance, direct transfers from government or NGOs
• Availability of markets	Principal component index based on a list of dummy variables assuming a value of 1 or 0 depending on whether the community has; a market selling agriculture inputs; a market selling agriculture produce; a market selling non-agriculture produce; a primary livestock market

• Availability of/access to communal natural resources	Principal component index based on a list of dummy variables assuming a value of 1 or 0 depending on whether the community has; communal crop land; communal pasture, communal forest, communal water bodies
• Availability of/access to infrastructure	weighted index based on the dummy variables capturing whether the community has; a tarmac road; murram road, feeder road, and community road
• Availability of/access to agricultural extension services	Whether there are agriculture extension service within the community.

Author's own construction 2020.

The constructed indexes are normalised to the range between 0 and 100 by using the formula;

$$index_{norm} = \left(\frac{x-min}{max-min}\right) * 100, \quad (22),$$

where $index_{norm}$ is the normalise index, x is the value of the index before normalising, min and max are the minimum and maximum values. Construction of the index is based on the pooled sample of the five waves. As such, normalisation is premised on the same base within the pooled sample which allows for comparison of the index overtime. Note, whereas this type of normalisation allows for comparison overtime and across households, it does not reveal information about absolute resilience. Therefore 0 and 100 should be treated as extreme points within the sample but not as absolute vulnerability and resilience respectively.

Table 3 shows the measured levels of resilience based on the methodology discussed above. Our analysis suggests that stagnation of resilience capacity index, with majority of the households being highly susceptible to the impacts of shocks due to low resilience capacity index. This suggests that majority of the households rely on negative coping strategies (such as selling assets, depletion of savings, changing diet patterns, borrowing) to deal with the impact of shocks, drought inclusive. This has adverse implications for resilience to future shocks. Furthermore, the distribution of all resilience capacities and overall resilience capacity index is skewed to the lower end (Figure 2), suggesting massive room for expansion of resilience capacity for majority of the households. Notably, there is a higher variation in adaptive capacity (especially at the higher levels of resilience) compared to absorptive and transformative, suggesting higher levels of inequality in terms of household resilience. The skewed distribution of resilience capacities suggested massive room for increasing resilience capacity of majority of the households in Uganda. Notably, households in Uganda exhibit relatively higher capacity to absorb o shocks, compared to adapting and transforming the impact of shocks (Table 3).

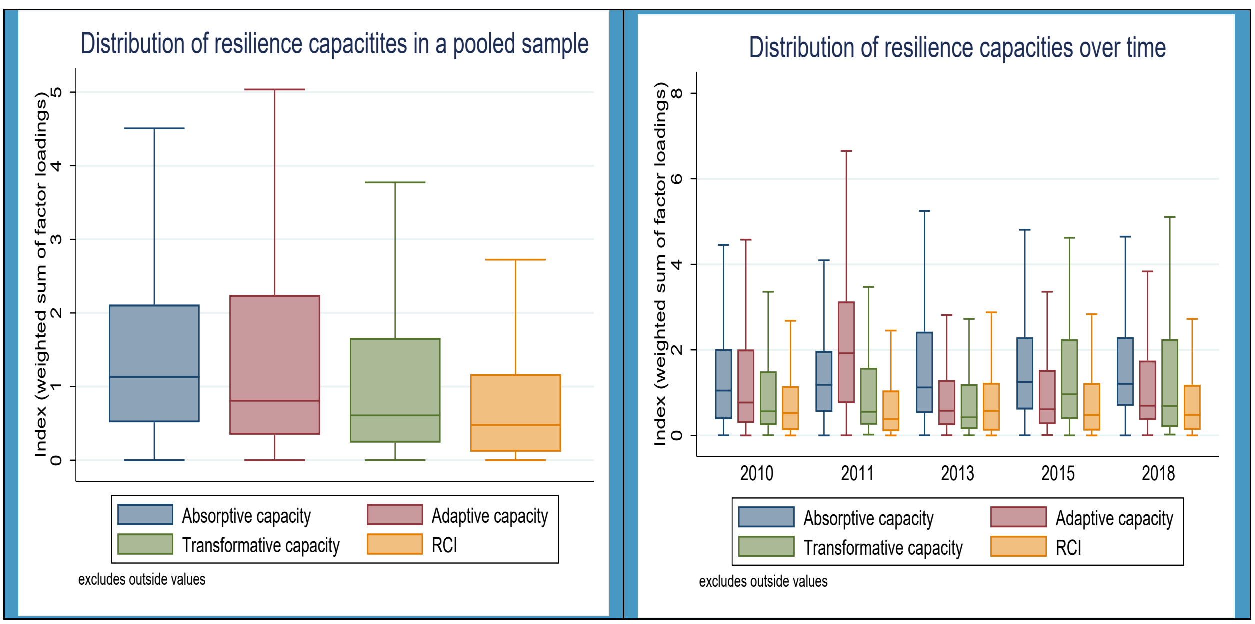
Table 3. Trends in estimated resilience capacities and resilience capacity index

Resilience capacities	2010/11	2011/12	2013/14	2015/16	2018/19	Average
Absorptive Capacity	31.4	33.4	35.2	37.2	37.0	34.8
Adaptive Capacity	29.3	47.2	23.1	26.6	27.8	30.8
Transformative Capacity	22.9	23.9	20.6	31.4	30.4	25.8
Resilience Capacity Index	29.9	27.9	31.4	31.3	30.5	30.2

Source: Author's own construction (2021) using data from UNPS 2010/11-2018/19.

Further descriptive analysis of the resilience capacity index and resilience capacities reveals that resilience capacities for Ugandan households are unstable and exhibit significant variation over time. Results in Table 4 show that households exhibit high within standard deviations for all resilience capacities, more so absorptive capacity. Given the stagnation in resilience capacities earlier observed, the high variation in resilience capacities alludes to limited capacity to sustain gains in household livelihoods and resilience in Uganda. Although the between variation is less than the within variation, it is also quite high, reaffirming high degree of inequality in term of resilience earlier observed. This implies that some households are highly vulnerable (most of whom are from the northern and eastern regions of the country) while others are highly resilient.

Figure 2. Distribution of resilience capacities



Source: Author's own construction (2021) using data from UNPS 2010/11-2018/19.

Table 4. Descriptive statistics for resilience capacities

Variables		Mean	Std. Dev.	Min	Max	Observations		
Resilience Capacity Index	Overall	29.6	21.5	0.1	89.7	N	=	2305
	Between		12.0	0.5	81.6	n	=	461
	Within		17.8	-36.1	95.6	T	=	5
Absorptive Capacity	Overall	35.1	32.1	0.0	100.0	N	=	2302
	Between		18.4	0.7	100.0	n	=	461
	Within		26.4	-35.4	112.5	T-bar	=	5
Adaptive Capacity	Overall	28.2	31.6	0.0	101.1	N	=	2302
	Between		18.5	2.3	101.1	n	=	461
	Within		25.6	-52.7	107.5	T-bar	=	5
Transformative Capacity	Overall	21.0	27.4	0.5	94.8	N	=	2305
	Between		15.8	2.3	94.8	n	=	461
	Within		22.4	-44.6	95.7	T	=	5

Source: Author's own construction (2021) using data from UNPS 2010/11-2018/19

Similar to D'Errico et al, (2018), results from factor analysis show that adaptive capacity contributes the highest to building resilience capacity among households in Uganda. More specifically, uniqueness values from factor analysis suggest that adaptive capacity if left alone would explain an average of 59 percent of the variation in resilience capacity index across the waves while transformative capacity and absorptive capacity would explain 38 percent 31 percent respectively (Table 5).

Further analysis shows that access to informal safety nets is the most important factor contributing to absorptive capacity of Ugandan households. Results suggest that informal safety nets, if left alone would individually explain an average of 97 percent of the variation in absorptive capacity across the waves (Table 5). This alludes to the need to reinvigorate informal safety nets such as saving groups, agriculture cooperatives, farmers' groups as a way of building households capacity to absorb shocks.

Regarding adaptive capacity, availability of financial services, *linking social capital* and exposure to information are the most important factors. For instance, availability of financial resources if left alone would explain 62 percent of the variations in adaptive capacity, *linking social capital* if left alone would explain 59 percent, while exposure to information would also explain 59 percent of the variations in adaptive capacity if left alone (Table 5). Transformative capacity is mainly driven by access to communal resources, availability/access to markets, and availability of extension services (Table 5).

Table 5. Factor analysis uniqueness values for the different components of resilience capacities

Components of resilience capacities	Factor 1	Factor 2	Uniqueness
Absorptive Capacity			
Availability of informal safety nets	-0.16	0.97	0.03
Access to remittances	0.73	-0.02	0.47
Asset ownership	0.71	0.24	0.45
Adaptive Capacity			
Linking Social capital	0.33	0.69	0.41
Human capital/education	0.73	-0.14	0.45
Livelihood diversification	0.55	-0.29	0.62
Exposure to Information	0.75	-0.16	0.41
Availability of financial resources	0.20	0.76	0.38
Transformative Capacity			
Access to formal safety nets	-0.04	-0.23	0.95
Availability of markets	0.71	-0.25	0.44
Access to communal natural resources	0.06	0.95	0.10
Availability/access to infrastructure	0.74	0.03	0.45
Availability of agricultural extension services	0.74	0.11	0.45
Resilience Capacity Index			
Absorptive Capacity	0.55	-	0.69
Adaptive Capacity	0.76	-	0.41
Transformative capacity	0.62	-	0.62

Source: Author's own construction (2021) using data from UNPS 2010/11-2018/19.

RESULTS AND DISCUSSION

As earlier mentioned, one of the potential sources of bias in the regression analysis is attrition which was addressed by estimating the attrition function. Indeed, results in Table 6 suggest that attrition was non-random and highly explained by some household demographics and location. Female headed, bigger households, and those headed by highly educated individuals were more likely to drop out of the sample (Table 6). Accordingly, attrition hazard was estimated and introduced in the outcome models (food security models) and a generated regressor. Whereas the significance tests on attrition hazard in the outcome models suggest presence of attrition for most of the models, there is no evidence of attrition bias in the coefficient estimates since the estimated coefficients before and after adjusting for attrition are close in magnitude and level of significance.

Table 6. Estimated marginal effects from the attrition function

Variables	Marginal effects for Probit estimation
Age of the household head	-0.021***
	(0.002)
Age squared	0.017***
	(0.002)
Gender (Ref: male)	
Female	0.044***
	(0.015)
Marital status (Ref: Unmarried)	
Married	-0.033**
	(0.016)
Household size	0.008***
	(0.002)
Education (Ref: Primary)	
Secondary	0.016
	(0.016)
Post-secondary	-0.036
	(0.030)
Degree and above	0.153***
	(0.045)
Region (Central)	
East	-0.076***
	(0.013)
North	-0.332***
	(0.014)
West	-0.190***
	(0.014)
N	7,388

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

Turning to the outcome models, our results are in line with previous studies (such as Funk et al., 2014; Watuleke, 2015; Akwango et al., 2017; Twongyirwe et al., 2019), whereby drought undermines food security by reducing both the amount of food consumed and the number of times households eat in a day (number of meals per day). Table 7 shows that households that report to have experienced drought are associated with 21 to 22% lower per capita food consumption and are likely to consume fewer meals compared to their counter parts. Remarkably, the adverse impact of drought on both per capita food consumption and meals consumed diminishes with the duration of drought although households still experience negative changes in food consumption (Table 7). Therefore, the onset of drought has more devastating effects on household food security. This suggests that households and humanitarian agencies are reactionary in nature, triggering resilience mechanisms after the shock has happened as opposed to building resilience exante.

Regarding resilience, results of the pooled sample show that increase in resilience capacity index enhance household's food security through both per capita food consumption and number of meals per day (regardless of the measure of drought incorporated in the model), although no significant impact is realized under the fixed effects estimation for meals per day and negative impact on per capita food consumption. More specifically, every one point gain in resilience capacity index results in 7 to 8 percent increase in per capita food consumption, other factors constant (Table 7 & 8; Model 1 and 3) depending on estimation technique. This implies that as a household becomes more resilient, it is able to increase both quantity of food consumed by each member and the number of times they eat in a day.

Results also show that resilience mitigates that adverse effects of self-reported drought especially after controlling for household fixed effects. The interactive terms between drought and resilience in Tables 7 and 8 (Models 2 and 4) show that household with high resilience capacity more likely to sustain their food consumption in the event of drought (since the coefficients are positive and significant).

Table 7. Drought (self-reported) and food security: Mitigating effect of RCI

	(1)	(2)	(3)	(4)	(5)	(6)
	Per capita food consumption			Number of meals per day by the HH		
	Pooled OLS	Fixed Effects	Attrition adjusted	Pooled OLS	Fixed Effects	Attrition adjusted
Drought dummy (Self-reported)	-0.221**	-0.208**	-0.212**	-0.167***	-0.133***	-0.163***
	(0.087)	(0.083)	(0.088)	(0.045)	(0.036)	(0.040)
Resilience Capacity Index (RCI)	0.096***	-0.056***	0.089***	0.033***	-0.008	0.029***
	(0.017)	(0.016)	(0.016)	(0.008)	(0.011)	(0.007)
Drought*RCI	-0.085*	0.093*	-0.079	-0.013	0.050**	-0.010
	(0.049)	(0.050)	(0.052)	(0.028)	(0.021)	(0.028)
Attrition hazard (χ^2)			7.52			6.30
Attrition hazard (p-value)			(0.006)			(0.012)
N	1,840	1,840	1,840	1,839	1,839	1,839

Note: Robust standard errors used in column 1 to 3. Bootstrap standard errors used in column (4) to (5). Additional covariates include age of the household head, age squared, gender of the household head, household size, marital, and status of the head

Source: Author's own construction using data from UNPS 2010/11 to 2018/19.

Table 8. Drought duration (self-reported) and food security: Mitigating effect of RCI

	(1)	(2)	(3)	(4)	(5)	(6)
	Per capita food consumption			Number of meals per day by the HH		
	Pooled OLS	Fixed Effects	Attrition adjusted	Pooled OLS	Fixed Effects	Attrition adjusted
Drought duration	-0.059**	-0.058**	-0.056***	--0.041***	-0.037***	-0.040**
	(0.026)	(0.024)	(0.022)	(0.014)	(0.011)	(0.016)
Resilience Capacity Index (RCI)	0.094***	-0.055***	0.087***	0.033***	-0.007	0.029***
	(0.017)	(0.016)	(0.018)	(0.008)	(0.011)	(0.009)
Drought duration*RCI	-0.019	0.028**	-0.017	-0.003	0.015**	-0.002
	(0.015)	(0.014)	(0.015)	(0.009)	(0.007)	(0.009)
Attrition hazard (χ^2)			7.52			6.30
Attrition hazard (p-value)			(0.006)			(0.012)
N	1,840	1,840	1,840	1,839	1,839	1,839

Note: Robust standard errors used in column 1 to 3. Bootstrap standard errors used in column (4) to (5). Additional covariates include age of the household head, age squared, gender of the household head, household size, marital, and status of the head

Source: Author's own construction using data from UNPS 2010/11 to 2018/19.

Notably, exogenous measure of drought (SPEI data) shows no significant impact of drought on per capita food consumption regardless of the estimation technique (Table 9 & 10, Models 1 to 3). However, households that experienced drought are likely to have fewer meals per day compared to those that did not experience drought regardless of the measure of drought and estimation technique (Table 9 & 10; Models 4 to 6). The consistency in the impact of self–reported and exogenous measures of drought on meals consumed by households suggests that drought in Uganda mainly affects own food production and less of food purchases possibly due to high regional interconnectedness which allows importation of food in the event of shortages. Given that majority of the vulnerable households rely on own food production, drought is likely to have devastating effects on food security.

Similar to self-reported shock, under the SPEI data, resilience enhances household's food security through both amount of food consumed and number of times they eat. In this regard, as resilience capacity increases, drought seizes to have a significant impact on meals consumed by a household (Table 9 & 10, Model 4 to 6). This implies an increase in resilience capacity prevents reduction in number of meals consumed by a household per day in the event of drought although the amount consumed may decline.

Table 9. Drought (SPEI) and food security: Mitigating effect of RCI

	(1)	(2)	(3)	(4)	(5)	(6)
	Per capita food consumption			Number of meals per day by the HH		
	Pooled OLS	Fixed Effects	Attrition adjusted	Pooled OLS	Fixed Effects	Attrition adjusted
Drought dummy (SPEI)	0.019	0.070	-0.009	-0.173***	-0.059**	-0.192***
	(0.074)	(0.065)	(0.065)	(0.035)	(0.030)	(0.035)
RCI	0.078***	-0.060***	0.072***	0.033***	-0.002	0.028***
	(0.020)	(0.016)	(0.018)	(0.009)	(0.011)	(0.009)
Drought*RCI	0.041	0.071**	0.041	0.001	0.003	0.001
	(0.039)	(0.029)	(0.038)	(0.020)	(0.015)	(0.020)
Attrition hazard (χ^2)			9.22			16.67
Attrition hazard (p-value)			(0.002)			(0.000)
N	1,840	1,840	1,840	1,839	1,839	1,839

Note: Robust standard errors used in column 1 to 3. Bootstrap standard errors used in column (4) to (5). Additional covariates include age of the household head, age squared, gender of the household head, household size, marital, and status of the head

Source: Author's own construction using data from UNPS 2010/11 to 2018/19.

Table 10. Drought severity (SPEI) and food security: mitigating effect of RCI

	(1)	(2)	(3)	(4)	(5)	(6)
	Per capita food consumption			Number of meals per day by the HH		
	Pooled OLS	Fixed Effects	Attrition adjusted	Pooled OLS	Fixed Effects	Attrition adjusted
Drought severity (SPEI dummy*SPEI index)	-0.091	0.102	-0.150	0.388***	-0.142*	-0.427***
	(0.199)	(0.188)	(0.209)	(0.082)	(0.074)	(0.085)
RCI	0.076***	0.060***	0.070***	0.031***	-0.001	0.026***
	(0.019)	(0.016)	(0.020)	(0.009)	(0.011)	(0.010)
Drought severity*RCI	0.173*	0.247***	0.163	0.008	-0.006	0.002
	(0.100)	(0.086)	(0.111)	(0.055)	(0.044)	(0.063)
Attrition hazard (χ^2)			14.78			15.13
Attrition hazard (p-value)			(0.000)			(0.000)
N	1,840	1,840	1,840	1,839	1,839	1,839

Note: *Robust standard errors used in column 1 to 3. Bootstrap standard errors used in column (4) to (5). Additional covariates include age of the household head, age squared, gender of the household head, household size, marital, and status of the head.*

Source: Author's own construction using data from UNPS 2010/11 to 2018/19.

Broadly and regardless of the measures of drought, our results confirm the assertion that households with weaker resilience capacities are more affected by or susceptible to drought (Shiferaw et al, 2014; Twongyirwe et al, 2019; Gerber & Mirzabaev 2017), offering support for the findings of d'Errico et al (2018) that resilience ameliorates the negative effect of drought on households' future food security. Accordingly, building household resilience is critical for mitigating the adverse effects of drought on food security.

Regression analysis based on the three resilience capacities reveals that absorptive significantly enhance per capita food consumption and the number of times households eat (under the pooled sample) regardless of the estimation technique and measure of drought controlled for (Table 11 to 13; Models 1, 3, 4 and 6). Adaptive and transformative capacities are only effective in enhancing per capita food consumption. Nonetheless, results suggest that increase in each of these capacities (where it's significant) results in more than proportionate increase in per capita food consumption.

In line with the arguments of Frankenberger & Smith (2015), we find the mitigating role of resilience on the impact of drought on food security to vary, depending on the resilience capacities possessed by households and the indicator of food security. Households with high adaptive capacity are more likely to be resilient to the adverse impacts of drought on food security by resisting a decline in the per capita food consumption and decline in number of meals for both self-reported (after adjusting for attrition under self-reported) and exogenous measure of drought (under the pooled sample) (Table 11 &12).

High transformative capacity ameliorates the negative impact of drought on per capita food consumption (shown by lower magnitude of the coefficients of interactive terms compared to the coefficients of drought in Table 11, Models 1 & 3), suggesting that households with absolute transformative capacity are only partially protected from the decline in amount of food consumed as a result of drought. However, transformative completely dampens the adverse effects of drought on number of times households eat but only with self-reported shock. Although the interactive term between drought (exogenous) and transformative capacity is positive under per capita consumption (Table 12-Model 2 &Table 13-Model 1 to 2), our earlier results show that per capita food consumption is a weak channel for the impact of drought (exogenous) on food security since majority of the household rely on own food production.13 Nonetheless, this suggests drought results in increase in food prices, leading to higher expenditures for households with higher transformative capacity. The mitigating effect of absorptive capacity only manifest with exogenous measure of drought and with regards to meals per day, possibly suggesting that self-reported measures underestimate the role absorptive capacity

Table 11. Drought (self-reported) and food security: Mitigating effect of resilience capacities

	(1)	(2)	(3)	(4)	(5)	(6)
	Per capita food consumption			Number of meals per day by the HH		
	Pooled OLS	Fixed Effects	Attrition adjusted	Pooled OLS	Fixed Effects	Attrition adjusted
Drought (self-reported)	-0.316***	-0.281***	-0.303***	-0.132***	-0.093**	-0.200***
	(0.099)	(0.094)	(0.097)	(0.041)	(0.040)	(0.043)
Absorptive capacity	0.033***	-0.008	0.033**	0.012***	0.006	0.017***
	(0.010)	(0.008)	(0.015)	(0.004)	(0.005)	(0.005)
Drought*Absorptive	0.011	0.030	0.014	0.004	0.003	0.012
	(0.031)	(0.023)	(0.033)	(0.011)	(0.011)	(0.024)
Adaptive capacity	0.034***	0.006	0.031***	0.002	-0.005	0.006*
	(0.008)	(0.008)	(0.009)	(0.004)	(0.004)	(0.003)
Drought*Adaptive	0.080*	0.106**	0.077*	-0.006	-0.023	0.032*
	(0.045)	(0.046)	(0.044)	(0.019)	(0.019)	(0.018)
Transformative capacity	0.020**	-0.007	0.017*	-0.001	-0.002	-0.002
	(0.008)	(0.008)	(0.010)	(0.004)	(0.005)	(0.004)
Drought*Transformative	-0.068***	-0.022	-0.067***	0.009	0.024**	-0.017
	(0.023)	(0.025)	(0.023)	(0.011)	(0.011)	(0.014)
Attrition hazard (χ^2)			5.52			8.02
Attrition hazard (p-value)			(0.019)			(0.005)
N	1,840	1,840	1,840	1,839	1,839	1,839

Note: *Robust standard errors used in column 1 to 3. Bootstrap standard errors used in column (4) to (5). Additional covariates include age of the household head, age squared, gender of the household head, household size, marital, and status of the head.*

Source: Author's own construction using data from UNPS 2010/11 to 2018/19.

[13] Our measure of per capita food consumption does not include own produced food

Table 12. Drought (SPEI) and food security: Mitigating effect of resilience capacities

	(1)	(2)	(3)	(4)	(5)	(6)
	Per capita food consumption			Number of meals per day by the HH		
	Pooled OLS	Fixed Effects	Attrition adjusted	Pooled OLS	Fixed Effects	Attrition adjusted
Drought dummy (SPEI)	-0.025	0.047	-0.045	-0.199***	-0.088***	-0.216***
	(0.079)	(0.072)	(0.085)	(0.036)	(0.032)	(0.040)
Absorptive Capacity	0.037***	-0.002	0.037***	0.018***	0.004	0.018***
	(0.010)	(0.008)	(0.010)	(0.004)	(0.005)	(0.005)
Drought*Absorptive	0.039	0.034	0.042	0.015	0.032**	0.018
	(0.036)	(0.033)	(0.057)	(0.017)	(0.016)	(0.021)
Adaptive Capacity	0.027***	0.011	0.025**	0.005	-0.007	0.003
	(0.010)	(0.009)	(0.012)	(0.004)	(0.005)	(0.005)
Drought*Adaptive	0.030	0.005	0.027	0.013**	-0.001	0.010
	(0.021)	(0.013)	(0.028)	(0.005)	(0.007)	(0.009)
Transformative capacity	0.011	-0.020**	0.008	-0.001	-0.001	-0.003
	(0.009)	(0.009)	(0.010)	(0.004)	(0.006)	(0.005)
Drought*transformative	0.008	0.033***	0.009	0.001	0.006	0.002
	(0.019)	(0.013)	(0.019)	(0.008)	(0.008)	(0.010)
Attrition hazard (χ^2)			6.33			24.89
Attrition hazard (p-value)			(0.012)			(0.000)
N	1,840	1,840	1,840	1,839	1,839	1,839

Note: *Robust standard errors used in column 1 to 3. Bootstrap standard errors used in column (4) to (5). Additional covariates include age of the household head, age squared, gender of the household head, household size, marital, and status of the head.*

Source: Author's own construction using data from UNPS 2010/11 to 2018/19.

The results suggest that, although households with strong adaptive capacity are generally more likely to resist the adverse impacts of drought on food security, there are specific aspects of absorptive capacity and transformative capacity that matter in overcoming the adverse impacts of drought. Accordingly, a detailed analysis of mitigating role of various components of the resilience capacities (Table 14 and 15) shows that; (i) access to information and linking social capital (proxied by quality of social services) are the most significant components of adaptive capacity (Table 14); (ii) access to better infrastructure services (Table 14), access to extension services; and communal resources (such as land) are the most critical for transformative capacity (Table 15); (iii) informal safety nets are critical for absorptive capacity (Table 15).

Table 13. Drought severity (SPEI) and food security: Mitigating effect of resilience capacities

	(1)	(2)	(3)	(4)	(5)	(6)
	Per capita food consumption			Number of meals per day by the HH		
	Pooled OLS	Fixed Effects	Attrition adjusted	Pooled OLS	Fixed Effects	Attrition adjusted
Drought severity (SPEI dummy*SPEI index)	-0.201	0.007	-0.247	-0.453***	-0.252***	-0.492***
	(0.225)	(0.217)	(0.216)	(0.085)	(0.079)	(0.089)
Absorptive capacity	0.041***	-0.004	0.041***	0.018***	0.004	0.018***
	(0.010)	(0.008)	(0.013)	(0.004)	(0.005)	(0.005)
Drought severity*Absorptive	-0.008	0.142	-0.002	0.044	0.120***	0.049
	(0.090)	(0.088)	(0.135)	(0.040)	(0.039)	(0.098)
Adaptive capacity	0.025**	0.009	0.022**	0.006	-0.006	0.004
	(0.010)	(0.009)	(0.011)	(0.004)	(0.005)	(0.006)
Drought severity*Adaptive	0.111**	0.029	0.103	0.027	-0.010	0.021
	(0.053)	(0.034)	(0.078)	(0.018)	(0.018)	(0.020)
Transformative capacity	0.008	-0.017**	0.005	-0.002	-0.002	-0.004
	(0.009)	(0.008)	(0.008)	(0.004)	(0.005)	(0.004)
Drought severity*Transformative	0.087*	0.107**	0.088*	0.009	0.025	0.009
	(0.052)	(0.046)	(0.050)	(0.028)	(0.028)	(0.031)
Attrition hazard (χ^2)			0.52			11.52
Attrition hazard (p-value)			(0.001)			(0.001)
Observations	1,840	1,840	1,840	1,839	1,839	1,839

Note: *Robust standard errors used in column 1 to 3. Bootstrap standard errors used in column (4) to (5). Additional covariates include age of the household head, age squared, gender of the household head, household size, marital, and status of the head.*

Source: Author's own construction using data from UNPS 2010/11 to 2018/19.

Table 14. Drought (Self-reported) and food security: Mitigating effect of different components of resilience capacities

	(1)	(2)	(3)	(4)	(5)	(6)
	Per capita food consumption			Number of meals per day by the HH		
	Pooled OLS	Fixed Effects	Attrition adjusted	Pooled OLS	Fixed Effects	Attrition adjusted
Absorptive capacity						
Drought*informal safety nets	0.007	0.004	0.009	-0.004	-0.022	-0.003
	(0.052)	(0.059)	(0.057)	(0.030)	(0.028)	(0.035)
Drought*Assets	-0.279***	-0.167	-0.280***	-0.107*	-0.088*	-0.107*
	(0.103)	(0.101)	(0.101)	(0.056)	(0.051)	(0.057)
Drought*remittances	-0.378	-0.350	-0.387	-0.177	-0.191*	-0.178
	(0.230)	(0.248)	(0.265)	(0.130)	(0.108)	(0.136)
Adaptive capacity						
Drought*linking social capital	0.049	0.023	0.049	0.046**	0.051**	0.046*
	(0.049)	(0.052)	(0.054)	(0.023)	(0.023)	(0.024)
Drought*livelihood diversification	-0.141	-0.185	-0.136	0.048	0.099	0.048
	(0.173)	(0.150)	(0.184)	(0.079)	(0.069)	(0.074)
Drought*access to information	0.496***	0.347***	0.496***	0.237***	0.138**	0.237***
	(0.130)	(0.126)	(0.125)	(0.077)	(0.069)	(0.084)
Drought*Financial services	-0.431**	-0.404	-0.415**	-0.234**	0.094	-0.233*
	(0.202)	(0.247)	(0.184)	(0.110)	(0.108)	(0.119)
Drought*formal education	0.179	0.371	0.161	0.056	0.064	0.055
	(0.223)	(0.239)	(0.251)	(0.090)	(0.088)	(0.113)
Transformative capacity						
Drought* access to markets	-0.056	0.005	-0.053	-0.041	-0.027	-0.041
	(0.053)	(0.060)	(0.057)	(0.031)	(0.029)	(0.037)
Drought*infrastructure	0.309***	0.193*	0.303***	-0.018	0.020	-0.018
	(0.092)	(0.099)	(0.100)	(0.043)	(0.038)	(0.048)
Drought*extension services	-0.112	-0.159**	-0.119	-0.023	-0.057*	-0.024
	(0.083)	(0.079)	(0.081)	(0.041)	(0.034)	(0.044)
Drought*communal resources	-0.168*	-0.181*	-0.174*	0.013	0.012	0.013
	(0.087)	(0.105)	(0.091)	(0.066)	(0.047)	(0.081)
Drought*formal safety nets	0.396	0.471	0.410	0.246	0.225	0.247
	(0.316)	(0.338)	(0.362)	(0.181)	(0.162)	(0.207)

Attrition hazard (χ^2)			4.51			-0.020
Attrition hazard (p-value)			(0.034)			(0.085)
N	1,530	1,530	1,530	1,530	1,530	1,530

Note: *Robust standard errors used in column 1 to 3. Bootstrap standard errors used in column (4) to (5). Additional covariates include age of the household head, age squared, gender of the household head, household size, marital, and status of the head.*

Source: Author's own construction using data from UNPS 2010/11 to 2018/19.

Table 15. Drought (SPEI) and food security: Mitigating effect of different components of resilience capacities

	(1)	(2)	(3)	(4)	(5)	(6)
	Per capita food consumption			Number of meals per day by the HH		
	Pooled OLS	Fixed Effects	Attrition adjusted	Pooled OLS	Fixed Effects	Attrition adjusted
Absorptive capacity						
Drought*informal safety nets	-0.025	0.002	-0.032	0.072***	0.046*	0.070***
	(0.045)	(0.048)	(0.044)	(0.025)	(0.025)	(0.024)
Drought*Assets	0.180**	0.016	0.172*	0.075*	0.039	0.073*
	(0.088)	(0.080)	(0.099)	(0.039)	(0.037)	(0.038)
Drought*remittances	-0.321	0.218	-0.339	-0.074	-0.185	-0.078
	(0.198)	(0.315)	(0.237)	(0.118)	(0.132)	(0.110)
Adaptive capacity						
Drought*linking social capital	0.157***	0.095**	0.154***	-0.045**	0.018	-0.045**
	(0.033)	(0.048)	(0.034)	(0.018)	(0.020)	(0.018)
Drought*livelihood diversification	0.208***	0.009	0.209***	-0.031	-0.010	-0.031
	(0.063)	(0.074)	(0.069)	(0.031)	(0.034)	(0.043)
Drought*access to information	0.005	0.090	0.009	-0.017	-0.098*	-0.017
	(0.134)	(0.133)	(0.142)	(0.056)	(0.056)	(0.064)
Drought*Financial services	-0.259	-0.077	-0.184	-0.085	-0.013	-0.069
	(0.238)	(0.291)	(0.249)	(0.138)	(0.169)	(0.153)
Drought*formal education	-0.226	-0.242	-0.218	-0.044	0.084	-0.042
	(0.164)	(0.193)	(0.170)	(0.078)	(0.081)	(0.085)
Transformative capacity						
Drought* access to markets	0.082	0.042	0.078	0.024	0.024	0.023
	(0.064)	(0.075)	(0.059)	(0.029)	(0.027)	(0.032)
Drought*infrastructure	-0.157*	-0.106	-0.155**	-0.030	-0.025	-0.030
	(0.083)	(0.071)	(0.079)	(0.037)	(0.036)	(0.033)
Drought*extension services	0.126*	-0.002	0.117	0.150***	0.022	0.148***
	(0.067)	(0.066)	(0.079)	(0.028)	(0.027)	(0.032)
Drought*communal resources	-0.028	-0.027	-0.014	0.143***	0.053	0.146***
	(0.070)	(0.071)	(0.078)	(0.044)	(0.044)	(0.042)
Drought*formal safety nets	0.627**	-0.144	0.654*	0.179	0.276	0.185
	(0.280)	(0.426)	(0.347)	(0.170)	(0.173)	(0.154)
Attrition hazard (χ^2)			3.06			0.58
Attrition hazard (p-value)			(0.080)			(0.448)
N	1,530	1,530	1,530	1,530	1,530	1,530

Note: *Robust standard errors used in column 1 to 3. Bootstrap standard errors used in column (4) to (5). Additional covariates include age of the household head, age squared, gender of the household head, household size, marital, and status of the head.*

Source: Author's own construction using data from UNPS 2010/11 to 2018/19.

CONCLUSION AND RECOMMENDATIONS

Due to the growing concern about the food security amidst continued climate shocks, especially drought in Uganda, this paper analyses the household resilience capacities with special focus on how different resilience capacities mitigate the impact of drought on food security in the country. Following the TANGO framework, indexes of three resilience capacities (absorptive, adaptive, and transformative) were constructed upon which the resilience capacity index was constructed and analyzed. In line with the TANGO framework, two-step factor analysis was adopted to develop resilience capacity index. Analysis of household resilience and food security was undertaken using panel data from the Uganda National Panel Surveys spanning five waves.

Our analysis shows that Ugandan households are remain susceptible to the negative impact of drought and other shocks due to persistently low resilience capacities. In addition, all resilience capacities exhibit skewed distribution towards the lower end, suggesting room for increasing resilience for majority of households. Results further show that adaptive capacity is the most contributing factor to household resilience followed by transformative capacity.

Regression analysis to establish the impact of drought on food security and the mitigating role of resilience on the impact of drought on food security was undertaken using pooled OLS and fixed effects estimation while controlling for potential attrition bias. Results confirm that drought undermines food security by affecting both amount of food consumed and the number of times households eat in a day. However, resilience capacity index is found to effectively dampen the negative impact of drought (with both self-reported and exogenous measures of drought), implying households with high resilience capacity are able to withstand the adverse effects of drought.

A breakdown into resilience capacities shows that adaptive capacity is the most effectively in mitigating the impact of drought food security. Nonetheless, there are specific aspects of absorptive capacity and transformative capacity that matter in overcoming the adverse impacts of drought. In this regard, a detailed analysis of the components of the three resilience capacities reveals that; access to information, access to better quality infrastructure and services (mainly extension services), access to communal resources (such as land), and informal safety nets are critical in mitigating the adverse impacts of drought. Our results therefore suggest that supporting households to build capacity to adapt to, transform, and absorb the impact of drought can help to reduce reliance on humanitarian assistance as this is hardly sustainable.

Based on the evidence in this paper, there is need to invest in early warning systems and enhance access to such climate related information to the vulnerable groups to enhance their preparedness and adaptation. It is also important to rejuvenate and support informal institutions such as women's groups, saving groups, mutual help groups, youth groups, agriculture cooperatives and other community-based associations. Government and development partners should work through these informal institutions to reach beneficiaries of various interventions as opposed to working directly to individual beneficiaries. Government of Uganda has established programs to help the youths (Youth

Livelihood Programme) and women (Uganda Women Entrepreneurship Programme) through groups. However, effectiveness of these programmes need to be enhanced by strengthening the linkage between financing and skills component to realize sustainable impacts. The proposed Parish Development Model presents an opportunity to leverage informal institutions by channeling the financial support through these groups. In addition, there is need to educate households about informal schemes and support formation of Rotating Saving and Credit Associations (ROSCA) and Village Saving and Loans Associations (VSLA). Agriculture cooperatives need to be awakened to support households to rely on agriculture for their livelihood.

There is also need for government to intervene in protection and maintenance of communally shared resources (such as communal crop land, forests water sources, irrigation schemes etc). Government also needs to actively engage local authorities to develop mechanisms that enable access to these resources by the vulnerable groups. In addition, agriculture extension services need to be enhanced-by recruiting extension officers where they are non-existent and adequately facilitating them to aid in adoption of improved agricultural practices and provision of improved inputs.

REFERENCES

Adelaja, A., George, J., Jayne, T., Muyanga, M., Awokuse, T., Liverpool-Tasie, L.S.O. and Aromolaran, A., 2020. Role of Resilience Factors in Mitigating the Negative Effects of Conflict on Land Expansion. Agricultural Policy Research in Africa (APRA). Working paper 45.https://www.future-agricultures.org/publications/working-papers-document/workingpaper-45-role-of-resilience-factors-in-mitigating-the-negative-effects-of-conflict-on-landexpansion/

Akwango, D., Obaa, B.B., Turyahabwe, N., Baguma, Y. and Egeru, A., 2017. Effect of drought early warning system on household food security in Karamoja subregion, Uganda. *Agriculture & Food Security*, *6*(1), p.43. https://doi.org/10.1186/s40066-017-0120x Alinovi, L., D'errico, M., Mane, E. and Romano, D., 2010. Livelihoods strategies and household resilience to food insecurity: An empirical analysis to Kenya. *European report on development*, pp.1-52.

Alinovi, L., Mane, E. and Romano, D., 2008. Towards the measurement of household resilience to food insecurity: applying a model to Palestinian household data. Deriving food security information from national household budget surveys. Food and Agriculture Organization of the United Nations, Rome, Italy, pp.137-152.

Ansah, I.G.K., Gardebroek, C. and Ihle, R., 2019. Resilience and household food security: A review of concepts, methodological approaches and empirical evidence. Food Security, 11(6), pp.1187-1203.

Asmamaw, M., Mereta, S.T. and Ambelu, A., 2019. Exploring households' resilience to climate change-induced shocks using Climate Resilience Index in Dinki watershed, central highlands of Ethiopia. *PloS one*, *14*(7), p.e0219393. https://doi.org/10.1371/journal.pone.0219393

Bahadur, A.V., Peters, K., Wilkinson, E., Pichon, F., Gray, K. and Tanner, T., 2015. The 3As: tracking resilience across BRACED. *Working and discussion papers*.

Barrett, C.B. and Lentz, E., 2013. Hunger and food insecurity. *The Oxford Handbook of Poverty and Society*.

Béné, C., Wood, R.G., Newsham, A. and Davies, M., 2012. Resilience: new utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes. *IDS Working Papers*, *2012*(405), pp.1-61. https://doi.org/10.1111/j.2040-0209.2012.00405.x

Bollen, K.A., 1989. (1989b). Structural equations with latent variables. New York: John Wiley.

Branch, A., 2018. From disaster to devastation: drought as war in northern Uganda. *Disasters*, *42*, pp.S306-S327. https://doi.org/10.1111/disa.12303

Carroll, N., Frijters, P. and Shields, M.A., 2009. Quantifying the costs of drought: new evidence from life satisfaction data. *Journal of Population Economics*, *22*(2), pp.445-461. https://doi.org/10.1007/s00148-007-0174-3

CDC, D.F., 2010. When Every Drop Counts—Drought Guidance for Public Health Professionals.

Cheng, T.C. and Trivedi, P.K., 2015. Attrition bias in panel data: a sheep in wolf's clothing? A case study based on the mabel survey. Health economics, 24(9), pp.1101-1117.

Choptiany, J., Graub, B., Dixon, J. and Phillips, S., 2015. Self-evaluation and holistic assessment of climate resilience of farmers and pastoralists (SHARP). *FAO, Rome*, *155*.

Cissé, J.D. and Barrett, C.B., 2018. Estimating development resilience: A conditional moments-

based approach. *Journal of Development Economics*, *135*, pp.272-284. https://doi.org/10.1016/j.jdeveco.2018.04.002.
Covarrubias, K.A., 2015. *The role of crop diversity in household production and food security in Uganda: A gender-differentiated analysis* (No. 2201-2019-1460).
d'Errico, M. and Pietrelli, R., 2017. Resilience and child malnutrition in Mali. Food security, 9(2), pp.355-370.
d'Errico, M. and Di Giuseppe, S., 2016. A dynamic analysis of resilience in Uganda.
d'Errico, M. and Di Giuseppe, S., 2018. Resilience mobility in Uganda: A dynamic analysis. World Development, 104, pp.78-96.
d'Errico, M., Romano, D. and Pietrelli, R., 2018. Household resilience to food insecurity: evidence from Tanzania and Uganda. Food Security, 10(4), pp.1033-1054.
d'Errico, M., & Smith, L., C. 2020. Comparison of FAO and TANGO measures of household resilience and resilience capacities.
Darnhofer, I., 2014. Resilience and why it matters for farm management. European Review of Agricultural Economics, 41(3), pp.461-484. https://doi.org/10. 1093/erae/jbu012
Dinkelman, T., 2017. Long-run Health Repercussions of Drought Shocks: Evidence from South African Homelands. *The Economic Journal*, *127*(604), pp.1906-1939. https://doi.org/10.1111/ecoj.12361
Duguma, M.K., Brüntrup, M. and Tsegai, D., 2017. Policy Options for Improving Drought Resilience and its Implication for Food Security. Studies 98. Deutsches Institut für Entwicklungspolitik. https://www.die-gdi.de/uploads/media/Study__98.pdf
Egeru, A., Osaliya, R., MacOpiyo, L., Mburu, J., Wasonga, O., Barasa, B., Said, M., Aleper, D. and Majaliwa Mwanjalolo, G.J., 2014. Assessing the spatio-temporal climate variability in semi-arid Karamoja sub-region in north-eastern Uganda. *International Journal of Environmental Studies*, *71*(4), pp.490-509. https://doi.org/10.1080/00207233.2014.919729
FAO, UNDP, UNICEF, WFP., 2015. Resilience to food insecurity and malnutrion in Karamoja, Uganda.
FAO. 2016b. Resilience index measurement and analysis (RIMA – II). Rome: FAO Available at: https://www.undrr.org/news/tackling-poverty-and-drought-uganda
FAO. 2017. The impact of disasters and crises on agriculture and food security
Faridi, R. and Wadood, S.N., 2010. An econometric assessment of household food security in Bangladesh. *The Bangladesh Development Studies*, pp.97-111. https://bids.org.bd/uploads/publication/BDS/33/33-3/04.pdf
Frankenberger, T., 2015. *Ethiopia Pastoralist Areas Resilience Improvement and Market Expansion (PRIME) Project Impact Evaluation Report of the Interim Monitoring*. Technical report, Westat, Rockville, MD.
Frankenberger, T., Mueller, M., Spangler, T. and Alexander, S., 2013. Community resilience: Conceptual framework and measurement feed the future learning agenda. Rockville, MD: Westat, 1.
Funk, C., Rowland, J., Eilerts, G., White, L., Martin, T.E. and Maron, J.L., 2012. A climate trend analysis of Uganda. *US Geological Survey Fact Sheet*, *3062*(4). https://pubs.usgs.gov/fs/2012/3062/
Gerber, N. and Mirzabaev, A., 2017. Benefits of action and costs of inaction: Drought mitigation and preparedness–a literature review. *World Meteorological Organization; Global Water Partnership, Working Paper Integrated Drought Management Programme Working*

Paper, *1*.
Gommes, R. and Petrassi, F., 1996. Rainfall variability and drought in sub-Saharan Africa. *SD dimensions, FAO*.
Graber, R., Pichon, F. and Carabine, E., 2015. Psychological Resilience: Capturing the State of the Research. Literature Review.
Guyomard, H., Darcy-Vrillon, B., Esnouf, C., Marin, M., Russel, M. and Guillou, M., 2012. Eating patterns and food systems: critical knowledge requirements for policy design and implementation. *Agriculture & Food Security*, *1*(1), p.13. https://doi.org/10.1186/20487010-1-13
Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D. and Vogt-Schilb, A., 2015. *Shock waves: managing the impacts of climate change on poverty*. The World Bank. http://hdl.handle.net/10986/22787
IPCC. 2001. Climate change Impacts, Adaptation, and Vulnerability. In: McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS (eds) Contribution of Working Group II to the Third Assessment Report. [Internet]. Cambridge University Press, Cambridge. Cambridge, UK.; 2001. Available: http://www.preventionweb.net/files/8387_wg2TARfrontmat%0Ater1. Pdf
Jones, L. and Samman, E., 2016. Measuring subjective household resilience: insights from Tanzania. *Overseas Development Institute (ODI). London: UK.*
Jones, L. and Tanner, T., 2017. 'Subjective resilience': using perceptions to quantify household resilience to climate extremes and disasters. *Regional Environmental Change*, *17*(1), pp.229243. https://doi.org/10.1007/s10113-016-0995-
Jones, L., Samman, E. and Vinck, P., 2018. Subjective measures of household resilience to climate variability and change. *Ecology and Society*, *23*(1). https://doi.org/10.5751/ES-09840230109
Kativhu, S., Mwale, M. and Francis, J., 2018. Approaches to measuring resilience and their applicability to small retail business resilience. *Problems and perspectives in management*, (16, Iss. 4), pp.275-284. https://www.researchgate.net/deref/http%3A%2F%2Fdx.doi.org%2F10.21511%2Fppm.16(4).2018.23
Knippenberg, E., Jensen, N. and Constas, M., 2019. Quantifying household resilience with high frequency data: Temporal dynamics and methodological options. World Development, 121, pp.1-15. https://doi.org/10.1016/j.worlddev.2019.04.010
Kyatengerwa, C., Kim, D. and Choi, M., 2020. A national-scale drought assessment in Uganda based on evapotranspiration deficits from the Bouchet hypothesis. *Journal of Hydrology*, *580*, p.124348. https://doi.org/10.1016/j.jhydrol.2019.124348
Levine, S., 2014. Assessing resilience: why quantification misses the point. Humanitarian Policy Group Working Paper. http://www.odi.org/sites/odi. org.uk/files/odi-assets/publicationsopinion-files/9049.pdf
Little, P.D., Stone, M.P., Mogues, T., Castro, A.P. and Negatu, W., 2006. 'Moving in place': drought and poverty dynamics in South Wollo, Ethiopia. *The Journal of Development Studies*, *42*(2), pp.200-225. https://doi.org/10.1080/00220380500405287
Lohmann, S. and Lechtenfeld, T., 2015. The effect of drought on health outcomes and health expenditures in rural Vietnam. *World development*, *72*, pp.432-448. https://econpapers.repec.org/scripts/redir.pf?u=https%3A%2F%2Fdoi.org%2F10.1016%252Fj.worlddev.2015.03.003;h=repec:eee:wdevel:v:72:y:2015:i:c:p:432-448

Napoli, M., De Muro, P. and Mazziotta, M., 2011. Towards a food insecurity Multidimensional Index (FIMI). *Master in Human Development and Food Security*, pp.1-72.

Pandey, S., Bhandari, H.S. and Hardy, B., 2007. *Economic costs of drought and rice farmers' coping mechanisms: a cross-country comparative analysis*. Int. Rice Res. Inst. http://books.irri.org/9789712202124_content.pdf).

Panu, U.S. and Sharma, T.C., 2002. Challenges in drought research: some perspectives and future directions. *Hydrological Sciences Journal*, *47*(S1), pp.S19-S30.

Pérez-Escamilla, R. and Segall-Corrêa, A.M., 2008. Food insecurity measurement and indicators. *Revista de Nutrição*, *21*, pp.15s-26s.

RIMA-II, F.A.O., 2016. Resilience Index Measurement and Analysis—II. *Food and Agriculture Organization of the United Nations: Rome, Italy*.

Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B.M. and Menkir, A., 2014. Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. *Weather and Climate Extremes*, *3*, pp.67-79. https://doi.org/10.1016/j.wace.2014.04.004

Smakhtin, V.U. and Hughes, D.A., 2004. *Review, automated estimation and analyses of drought indices in South Asia* (Vol. 83). Iwmi.

Solh M. & Ginkel M. V. 2014. Drought preparedness and drought mitigation in the developing worlds' drylands. https://doi.org/10.1016/j.wace.2014.03.003

Tate, E.L. and Gustard, A., 2000. Drought definition: a hydrological perspective. In *Drought and drought mitigation in Europe* (pp. 23-48). Springer, Dordrecht.

Ulrichs, M., and Slater, R., 2017. How is social protection building resilience in Uganda? BRACED Policy Brief, pp.1-4.

Upton J., Constenla-Villoloda S., Barret C., 2020. A comparative assessment of resilience measurement approaches

Vaitla, B., Cissé, J.D., Upton, J., Tesfay, G., Abadi, N. and Maxwell, D., 2020. How the choice of food security indicators affects the assessment of resilience—an example from northern Ethiopia. Food Security, 12(1), pp.137-150.

Van Loon, A.F. and Van Lanen, H.A.J., 2011. A process-based typology of hydrological drought. *Hydrology & Earth System Sciences Discussions*, *8*(6).

Verner, D., Treguer, D., Redwood, J., Christensen, J., McDonnell, R., Elbert, C., Konishi, Y. and Belghazi, S., 2018. *Climate Variability, Drought, and Drought Management in Morocco's Agricultural Sector*. World Bank. http://hdl.handle.net/10986/30603

Vicente-Serrano, S. M., Beguería, S., & López-Moreno, J. I. (2010). A multiscalar drought index sensitive to global warming: the standardized precipitation evapotranspiration index. Journal of climate, 23(7), 1696-1718.

Vicente-Serrano, S. M., Beguería, S., Lorenzo-Lacruz, J., Camarero, J. J., López-Moreno, J. I., Azorin-Molina, C. & Sanchez-Lorenzo, A. (2012). Performance of drought indices for ecological, agricultural, and hydrological applications. Earth Interactions, 16(10), 1-27.

Vu, L. and Glewwe, P., 2011. Impacts of rising food prices on poverty and welfare in Vietnam. *Journal of Agricultural and Resource Economics*, pp.14-27. https://www.researchgate.net/deref/http%3A%2F%2Fdx.doi.org%2F10.22004%2Fag.econ.105512

Walker, B., Holling, C.S., Carpenter, S.R. and Kinzig, A., 2004. Resilience, adaptability and transformability in social–ecological systems. *Ecology and society*, *9*(2). https://doi.org/10.1103/PhysRevLett.95.258101

Watuleke, J., 2015. *The role of food banks in food security in Uganda: the case of the Hunger Project Food Bank, Mbale Epicentre*. Nordiska Afrikainstitutet.

World Bank., 2010. World Development Report 2010: Climate change and development. Washington, DC.

Habtamu Taddele Menghistu, Tadesse Teferi Mersha and Amanuel Zenebe Abraha (2018) Farmers' perception of drought and its socioeconomic impact: the case of Tigray and Afar regions of Ethiopia, Journal of Applied Animal Research, 46:1, 1023-1031, DOI: 10.1080/09712119.2018.1450752