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IMPACT OF DROUGHT ON POVERTY IN SOMALIA

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ABSTRACT

Understanding the magnitude and importance of income shocks, such as drought or conflict, in causing and perpetuating poverty is critical to designing policies aimed at building resilience and contributing toward the goal of ending poverty. This paper uses micro-data from two waves of the Somali High Frequency Survey to assess the impact of the severe drought that Somalia experienced in 2016/17 on poverty, hunger, and consumption. The analysis uses a regression framework to quantify the effects of the drought, relying on spatial variation in drought exposure and the timing of data collection, which took place before and during the drought, for identification. The drought is found to have a sizable effect on poverty, consumption, and hunger in rural areas, where agricultural households and those lacking access to infrastructure and basic services are most severely affected. A renewed drought shock could lead to an increase in poverty of 9 percentage points. The findings underscore the importance of investing in rural resilience, especially among agricultural households.

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Impact of Drought on Poverty in Somalia

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1. Introduction

The impact of adverse climatic, and other, income shocks on household and individual welfare in developing countries is an issue of considerable policy interest. Understanding the magnitude and importance of income shocks in causing and perpetuating poverty is critical to designing measures aimed at building resilience, contributing towards the goal of ending poverty. A growing body of literature provides empirical evidence of the micro-level impacts of adverse shocks in developing countries. Dercon and Krishnan (2000), Dercon (2004), and Porter (2012) find that weather shocks have a negative and long-lasting effect on consumption outcomes in rural Ethiopia. Hill and Porter (2016) and Makoka (2008) show that drought and price shocks reduce consumption and especially farm income, while increasing vulnerability to poverty in rural Ethiopia and Malawi, respectively. Similarly, Alem and Soderbom (2012) conclude that high food prices adversely affect households in urban Ethiopia, especially those relying on casual work and with low asset levels. Hill and Mejia-Mantilla (2017) find negative effects of drought, conflict, and prices on poverty levels in Uganda, and Pape and Parisotto (forthcoming) find a large and significant impact of conflict on poverty in South Sudan. Hoddinott and Kinsey (2001) and Alderman et al. (2006) show the causal relation between rainfall shocks and reduced human capital formation.

This paper contributes to the existing literature, by focusing on the impact of drought on poverty in Somalia. Four consecutive seasons of poor rains between April 2016 and December 2017 resulted in a severe drought across Somalia (FEWSNET, 2018). The drought exacerbated preexisting food insecurity, as half of the population faced acute food insecurity in mid-2017 (FEWSNET, 2016; FSNAU, 2017). The drought threatened the livelihoods of many Somalis. Lack of water and pasture led to high livestock deaths and low birth rates, and induced distress selling caused the 26 percent of Somalis relying on livestock for their livelihoods to lose between 25 and 75 percent of their herds in the first half of 2017 (FEWSNET, 2018). Households depleted productive assets and food stocks to cope with the rising food and water prices, while weak demand for labor in the agricultural sector led to lower wage levels (FEWSNET, 2017a). As a result, the drought displaced close to one million people between 2016 and 2017. Large-scale humanitarian interventions provided critical relief to up to 3 million people to reduce the risk of famine (FEWSNET, 2017b).

Using data from two waves of the Somali High Frequency Survey (SHFS), this analysis employs a regression framework to measure the micro-level impact of the 2016/17 drought on poverty. It exploits spatial variation in the intensity of drought that different households experienced and compares consumption before and after the drought. Households' level of drought exposure is measured by using the Normalized Difference Vegetation Index (NDVI). The temporal difference is provided by the timing of the first two waves of the SHFS. The first wave took place before the onset of the drought in early 2016, while the second wave surveyed households in late 2017, when the drought had surpassed its peak.

The remainder of this paper is structured as follows. Section 2 describes the data used to measure the impact of drought on poverty. Section 3 outlines the identification and estimation strategy. Section 4 presents the results, and section **Error! Reference source not found.** tests the robustness of these results. Section 6 concludes with a discussion of the results and discusses policy recommendations.

2. Data

This analysis uses cross-sectional household-level data from two waves of the SHFS. Wave 1 interviewed 4,117 urban, rural, and IDP households in February and March of 2016, representative of 9 of 18 Somali pre-war regions, excluding inaccessible areas in the south. Wave 2 expanded coverage to all but one,

inaccessible pre-war region, and included the nomadic population, interviewing a total of 6,092 households in December 2017 (Table 1).

Table 1: Number of interviews by population type, Somali High Frequency Survey

Population type	Wave 1 households	Wave 2 households
Urban	2,864	4,011
Rural	822	1,106
IDP	431	468
Nomadic	0	507
Total	4,117	6,092

Source: Authors' calculations.

The analysis excludes nomadic households and IDPs within and outside IDP settlements to avoid invalid comparisons between wave 1 and wave 2. Large-scale drought-related displacement implies that IDP populations before the drought in wave 1 were different from IDP populations surveyed during the drought in wave 2. Nomadic households do not have a permanent place of residence, so that a geographical exposure measure cannot be assigned in a meaningful way. The final data set contains 5,852 urban and 1,594 rural households. The data include information on consumption and key household and individual characteristics and perceptions, as well as information on shocks and vulnerabilities. Poverty is measured against the international poverty line of US$ 1.90 per capita per day, derived from the spatially and intertemporally deflated consumption aggregate (Pape and Wollburg, forthcoming).

The Normalized Deviation Vegetation Index (NDVI) is used to determine the exposure of households to the drought. The NDVI is derived from satellite images measuring the health of vegetation. Below-average NDVI values imply drier-than-usual conditions, indicating the vegetation health is also below-average. NASA's MODIS Terra and Aqua platform provides the daily global NDVI data at 500m resolution, which serve as the source of data for this analysis (Schaaf, 2015). While four consecutive rainy seasons delivered poor rains in 2016 and 2017, the severe rainfall deficits in the second rainy season of 2016 and first rainy season of 2017 were the key drivers of the 2016/17 drought in Somalia (FEWSNET, 2018).[2] Hence, each household's level of drought exposure is defined in this analysis as the percentage deviation of the NDVI during these two seasons from the pre-drought 2012 to 2015 average,[3] within a 25km radius around each household. The levels of drought exposure range from NDVI values of 6 percent above average to 20 percent below average in wave 1, and from 4 percent above average to 36 percent below average in wave 2, reflecting the overall spectrum of drought severity (Figure 1).

[2] Somalia has two main rainy seasons: the main Gu rains from April to June and the short Deyr rains from October to December. Significantly below-average rainfall started with the 2016 Gu rains and extended to the 2017 Deyr rains.

[3] In 2010-11, there was a severe drought in Somalia. The reference period was chosen to start after the 2010-11 drought to preclude this unusual event from interfering with the series average, following World Bank (2018).

Figure 1: Distribution of NDVI distribution, all Somalia, wave 1 and wave 2 households

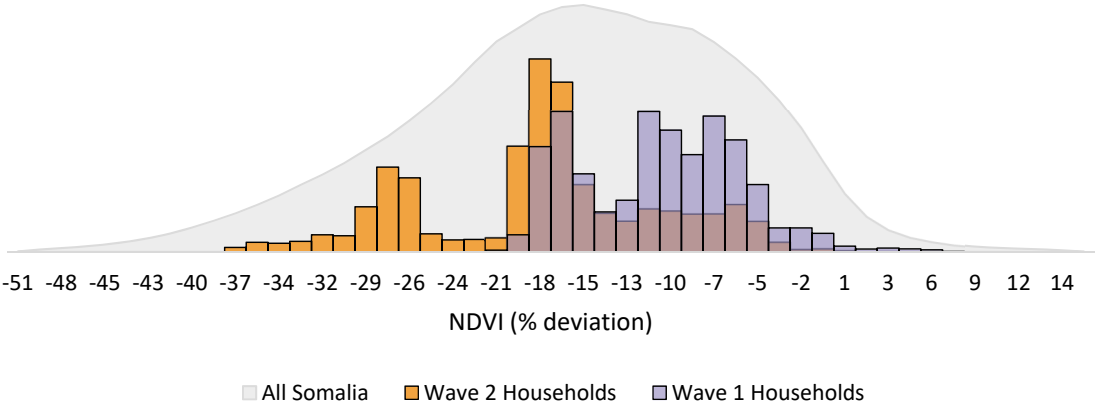


Figure 2: NDVI deviation, 2016 Deyr season

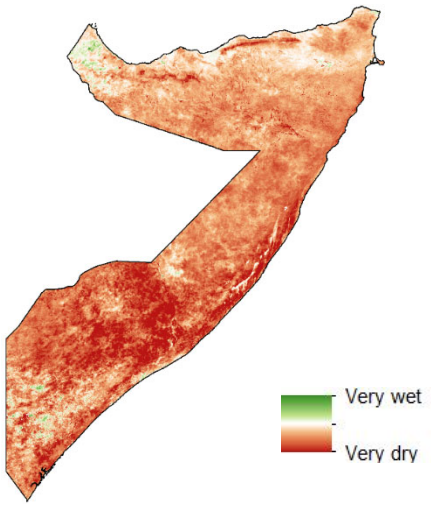
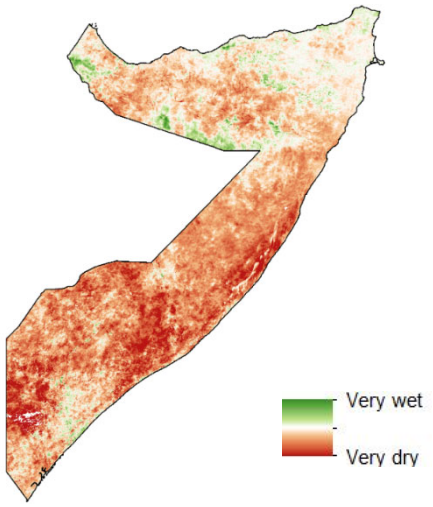


Figure 3: NDVI deviation, 2017 Gu season



Source: Authors' calculations based on MODIS NDVI data.

In controlling for potential confounding factors, we rely on geo-coded conflict fatality data provided by the Armed Conflict Location Event Dataset (ACLED) and on data on the percentage of target beneficiaries reached with aid by pre-war region coming from the Food Security Cluster Somalia (Table A.1).

3. Methodological approach

This analysis uses a regression framework similar to Hill and Porter (2016) to estimate the effect of the drought on poverty and consumption. To isolate the drought effect, the analysis exploits two characteristics of the SHFS data set. First, fieldwork timing was such that data were collected before the drought shock (wave 1) and during the drought (wave 2), allowing for a before-and-after comparison. Second, there was spatial variation in households' exposure to drought, with some in highly and others in less drought-affected areas (Figure 1; Figure 2; Figure 3). The analysis compares how much poverty and consumption changed between wave 1 and wave 2 for households in highly drought-exposed areas relative to households in less drought-exposed areas, which can be written as

$$Y_{it} = \beta_0 + \beta_1 post_t + \beta_2 DroughtIntensity_i + \beta_3 post_t * DroughtIntensity_i + \varepsilon_{it} \quad (1)$$

Here, Y_{it} denotes outcomes of interest for household *i* at time *t*, primarily the poverty headcount rate. $post_t$ is a binary variable indicating time period *t* (wave 1, wave 2) and $DroughtIntensity_i$ is the continuous treatment variable, indicating the level of drought exposure of household *i* in standard deviations of NDVI anomaly from the 2012 to 2015 average. ε_{it} denotes the error term. β_0 is the intercept, β_1 is the expected mean change in outcome from wave 1 to wave 2. The coefficient of the drought exposure variable, β_2, is the estimated mean difference in outcomes prior to the drought: it represents whatever baseline differences existed between households before exposure to the drought. The coefficient of interest is β_3, which estimates the drought effect.

In (1), if households in highly drought-exposed areas experienced a larger increase in poverty than households in less drought-exposed areas, the interpretation is that drought increased poverty. The validity of this conclusion rests on the assumption that households in wave 1 and wave 2 and in highly and less drought-affected areas make for good comparison groups, so that exposure to drought can be thought of as exogenous.

This assumption may be violated for several reasons. First, there may be factors that affect the outcome variables at the same time as the drought, such as conflict or humanitarian assistance. Second, the use of repeated cross-sectional data does not allow for household-level fixed effects to control for all baseline differences. Critically, some regions may be inherently more likely than others to experience drought. Therefore, a vector of control variables $\boldsymbol{X}_{it}$ is introduced, such that equation (1) becomes

$$Y_{it} = \beta_0 + \beta_1 post_t + \beta_2 DroughtIntensity_i + \beta_3 post_t * DroughtIntensity_i + \beta_4 \boldsymbol{X}_{it} + \varepsilon_{it} \quad (2)$$

As a proxy for the region's propensity to experience drought, $\boldsymbol{X}_{it}$ includes a measure of the medium-term (2002 to 2013) deviation from the NDVI average for each region surveyed (Hill and Mejia-Mantilla, 2017). Price levels are a further potential confounding factor and are therefore included in $\boldsymbol{X}_{it}$. Further control variables fall into five categories: regional and population-type controls, household characteristics, dwelling characteristics, exposure to conflict, and humanitarian assistance (see Table A.1).

Equation **Error! Reference source not found.** is implemented with OLS, Probit, or quantile regressions, depending on the objective at hand: when the dependent variable is binary, as is the case with poverty and hunger, Probit is used. When the depending variable is continuous, as with consumption, OLS is more appropriate. Quantile regressions are used to understand the drought impact along the entire consumption distribution, to gauge whether the drought affected households at different welfare levels differentially.

The drought impact is estimated from the full set of urban and rural households surveyed in wave 1 and wave 2 of the SHFS. Geographical coverage across waves was different, as additional regions were surveyed in wave 2 (Figure A.1; Figure A.2). The lack of complete geographical overlap impedes controlling for regional idiosyncrasies of regions covered in wave 2 only at baseline. As a robustness check, we present a specification of only overlapping wave 1 and wave 2 areas, allowing for a genuine region fixed effect. The additional specification restricts the analysis to urban households in Mogadishu and the north-west and to rural households only in the north-west. This limits the appeal of the additional specification because it reduces the analysis to estimating a localized rather than global drought-effect.

4. Results

We find that, in rural areas, more drought-exposed households experienced a significant reduction in consumption and increase in poverty. An increase of one standard deviation in drought exposure during the 2016/17 drought led to a decline in household consumption of 26 percent, based on the preferred regression specification with the full set of controls. One standard deviation increase in drought exposure corresponds to a seven percentage-point negative anomaly in NDVI, relative to the pre-drought average. This reduction in consumption corresponds to an increase of 15 percent in the probability of being poor (Table 2, column III). The drought had no significant effect on poverty in consumption in urban areas, nor in the combined sample of urban and rural households (Table 2, column I and II; Table A.2).

Table 2: Drought impact on poverty and consumption.

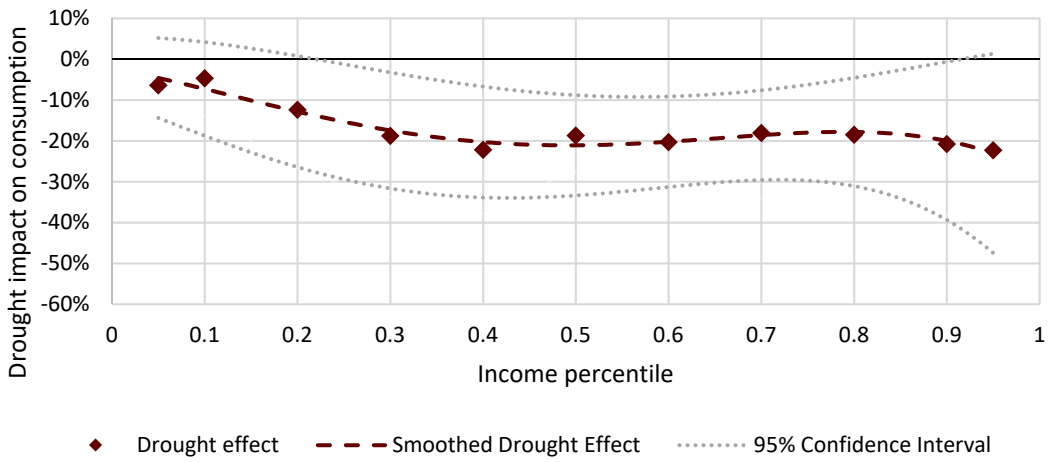
	(I)	(II)	(III)
Sample	Full urban + rural sample	Full urban sample	Full rural sample
Outcome variable (Yit)		Poverty Status	
Drought Impact	-0.00535	-0.0201	0.264***
S.E.	(0.0508)	(0.0568)	(0.0812)
Outcome variable		ln(Core Consumption)	
Drought Impact	1.59e-05	0.0286	-0.146**
S.E.	(0.0386)	(0.0345)	(0.0665)
Controls (Xit)	Yes	Yes	Yes
Observations	7,214	5,678	1,536
R-squared	0.352	0.345	0.522

Source: Authors' own calculations.

Note: ***p<0.01, **p<0.05, *p<0.1. Poverty status results estimated using Probit, Consumption results estimated using OLS. Drought effect expressed in standard deviations of NDVI loss.

Implementing equation (2) with controls through quantile regressions allows assessing the drought's impact on consumption at different points along its distribution. In rural areas, the drought's impact on consumption was smaller for the poorest households. Higher drought exposure had no significant impact on consumption for the poorest 10 percent of rural households, reduced consumption by 17 percent for rural households at the twentieth percentile, and between 20 and 25 percent for the top 80 percent of rural households (Figure 4). In urban areas, the impact is around zero across the income distribution (Figure A.3).

Figure 4: Drought effect along the consumption expenditure distribution, rural areas.

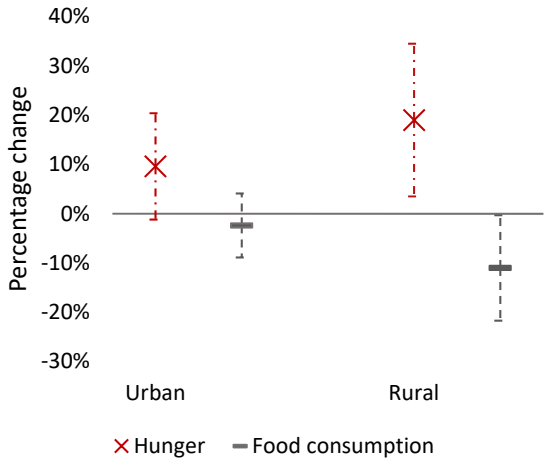


Source: Authors' calculations.

Varying levels of drought exposure along the consumption distribution do not explain these differences, as the median drought intensity among the poorest 10 percent of households is similar to the overall average drought exposure. With an average poverty gap of 72 percent, this group is very poor. These households may have relied on humanitarian assistance already before the onset of the drought, thus being isolated from the impact of the drought on consumption.

More drought exposed households were also more likely to experience hunger. As levels of hunger rose across all Somali regions, rural households in highly drought-exposed areas were most severely affected. Higher drought exposure led to an 11 percent decrease in food consumption, accompanied by a 19 percent increase in the probability of experiencing hunger in December 2017. The effect is much less pronounced among urban households (Table A.3; Table A.4).

Figure 5: Drought effect on hunger and food consumption.



Source: Authors' calculations.

5. Robustness

The robustness of this analysis' main findings on the drought impact on rural poverty is verified in several ways. First, the results' sensitivities to the inclusion and exclusion of various groups of control variables are tested. The results are robust across all tested specifications, and do not depend on the inclusion of certain groups of control variables. With the inclusion of subsequent groups of control variables, the drought impact point estimates vary between 19 and 30 percent increase in the probability of being poor.

Table 3: Robustness of results across various specifications.

	(I)	(II)	(III)	(IV)	(V)	(VI)
Sample	Full rural sample					
Outcome variable	PoorPPP					
Drought Impact	0.192***	0.256***	0.222***	0.230***	0.301***	0.264***
S.E.	(0.0629)	(0.0733)	(0.0679)	(0.0739)	(0.0769)	(0.0812)
Outcome variable	ln(Core Consumption)					
Drought Impact	-0.107**	-0.189***	-0.146***	-0.152***	-0.169**	-0.146**
S.E.	(0.0428)	(0.0598)	(0.0555)	(0.0551)	(0.0668)	(0.0665)
Controls						
Regional	No	Yes	Yes	Yes	Yes	Yes
Household	No	No	Yes	Yes	Yes	Yes
Dwelling	No	No	No	Yes	Yes	Yes
Conflict	No	No	No	No	Yes	Yes
Assistance	No	No	No	No	No	Yes
Observations	1,591	1,591	1,563	1,536	1,536	1,536
R-squared	0.032	0.226	0.359	0.487	0.501	0.522

Source: Authors' calculations.

Note: ***p<0.01, **p<0.05, *p<0.1. Poverty status results estimated using Probit, Consumption results estimated using OLS. Drought effect expressed in standard deviations of NDVI loss.

Second, the analysis is replicated on households only in regions overlapping between wave 1 and wave 2 of the SHFS. This reduces the geographical scope of the analysis to rural areas in the north-west of Somalia and to urban areas in the north-west and Mogadishu. The results from this subsample are in line with the main findings from the full sample of households (Table A.5). In rural areas, more drought-exposed households are 36 percent more likely to be poor, experiencing a 15 percent reduction in consumption, slightly higher than the 26 and 15 percent, respectively, in the full sample. No significant effect was found in urban areas.

Third, the sample is restricted by iteratively removing from the analysis households from north-eastern regions (Table 4, columns I and II), central regions (Table 4, columns III and IV), and south-western regions (Table 4, columns V and VI). The main results are largely unchanged when removing north-eastern regions, while a larger drought effect is found when removing south-western households. In contrast, the results are weaker when excluding central regions, though point estimates are still in a similar range. This indicates that the drought effect was weaker in south-west and particularly strong in central regions.

Table 4: Regression results with restricted samples.

Sample	Rural, NE excluded	Rural, Central excluded	Rural, SW excluded

Outcome variable	Poverty					
Drought Impact	0.197***	0.251***	0.137**	0.201***	0.224***	0.424***
S.E.	(0.066)	(0.082)	(0.038)	(0.051)	(0.059)	(0.074)
Outcome variable	ln(Core Consumption					
Drought Impact	-0.129***	-0.149**	-0.051	-0.071	-0.128***	-0.195***
S.E.	(0.048)	(0.075)	(0.038)	(0.051)	(0.043)	(0.057)
Controls	No	Yes	No	Yes	No	Yes
Observations	1,511	1,456	1,087	1,035	1,319	1,277
R-squared	0.054	0.508	0.029	0.507	0.065	0.561

Source: Authors' calculations.

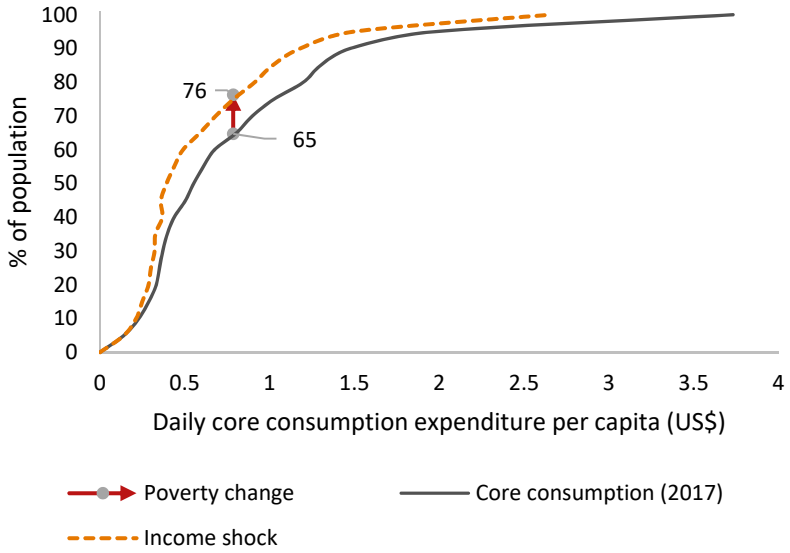
Note: ***p<0.01, **p<0.05, *p<0.1. Poverty status results estimated using Probit, Consumption results estimated using OLS. Drought effect expressed in standard deviations of NDVI loss.

6. Discussion and conclusions

The results show that the 2016/17 drought severely affected consumption in rural households. The magnitude of the drought impact is generally in line with findings in the literature, but on the upper end of the reported effects. For example, Hill and Porter (2016) find that a moderate drought shock leads to a 9 percent reduction in consumption in Uganda, while this analysis finds an effect almost double that size. However, given the severity of the 2016/17 drought in Somalia, the results appear consistent.

Droughts are cyclical events in Somalia and the Horn of Africa region in general. Recently, severe droughts affected Somalia in 2011 and 1991. A renewed drought shock is therefore likely very to occur at some point in the future. The detailed results from the regression analysis allow to simulate how a renewed income shock of the same magnitude as the 2016/17 drought would affect rural households. To model another income shock, the quantile regression estimates of the drought's effect on household consumption at different points along its distribution are applied to the SHFS data. Based on this simulation, a renewed income shock could increase rural poverty by nine percentage points, from 65 to 76 percent (Figure 6).

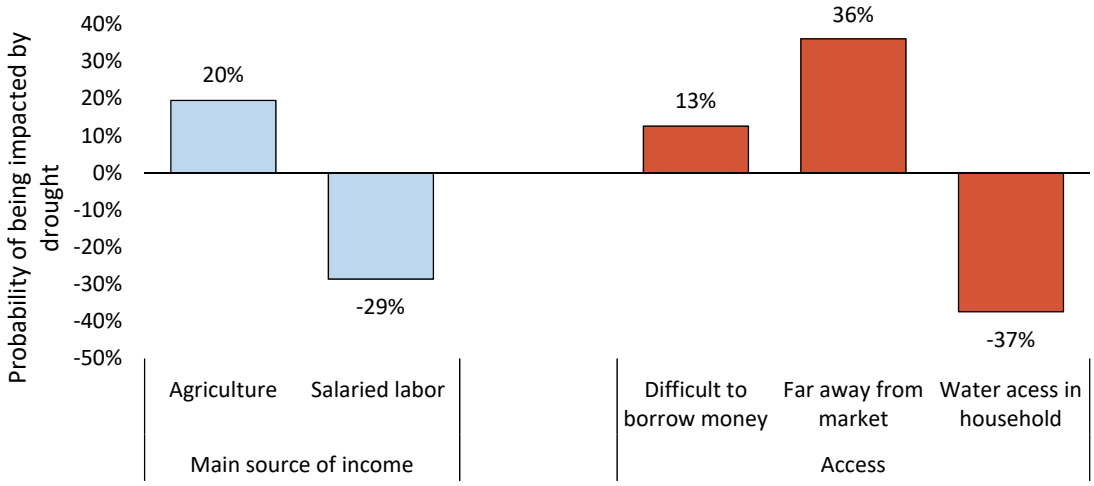
Figure 6: Simulation of income shock among rural households.



Source: Authors' calculations.

The simulation results emphasize that a sustainable poverty reduction strategy should involve making rural households more resilient to climatic income shocks. To guide such efforts, it is instructive to analyze the characteristics of the most affected rural households. To do this, we focus on which households self-reported having been affected by the 2016/17 drought, regressing it on household characteristics while controlling for location, income, and households' exogenous level of drought exposure as measured with NDVI. First, households relying on agricultural income are 20 percent more likely to report being affected by the drought. In contrast, households relying on salaried labor are significantly less likely to report being affected by the drought (Figure 7). The fact that households relying on agricultural income are mainly in rural areas is likely part of the reason why no drought effect was found in urban areas. The particular vulnerability to drought shocks of agricultural households is also well-documented in the literature (e.g. Hill and Mejia-Mantilla, 2017). This set of findings suggests that agricultural households may benefit from insurance products, such as agricultural index insurance (see Berhane et al., 2012; Dercon et al., 2014). Further, measures facilitating the diversification of income sources, especially the shifting of household members towards wage jobs, could help cushion the effect of climatic shocks (Alem and Soderbom, 2012).

Figure 7: Correlates of drought-impacted rural households.



Source: Authors' calculation.
Note: Coefficients from Probit regression with self-reporting to be impacted by the drought as dependent variable. Regression with controls for drought-exposure measured by NDVI, household income, and region. All reported results significant at the 5%-level.

Second, rural households without access to water in the dwelling, agricultural households more than an hour away from the nearest food market, and households who struggle to borrow money in an emergency were also more likely to be impacted by the drought (Figure 7). While the latter is another indication of the usefulness of agricultural insurance, these results show that households lacking access to infrastructure and services are also particularly vulnerable. Investments in infrastructure and basic services could thus improve rural households' resilience.

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Appendix

Figure A.1: Coverage wave 1

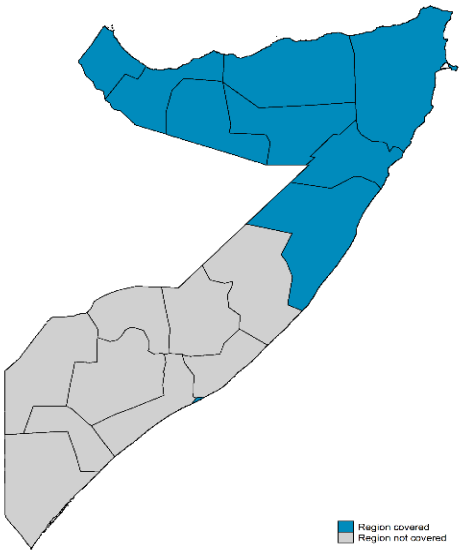


Figure A.2: Coverage wave 2

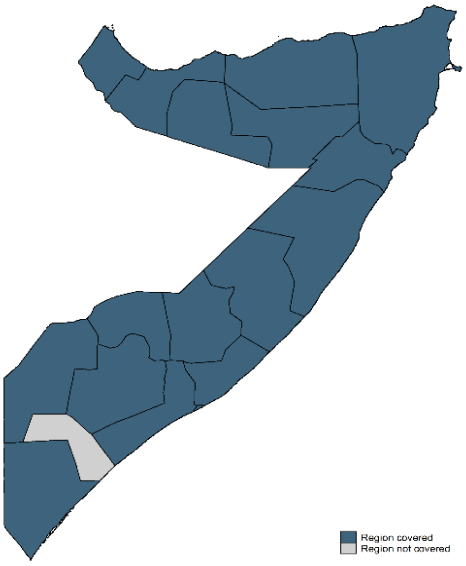


Table A.1: List of control variables for the regression analysis.

Variable	**Description**	**Source**
Average NDVI	Average value of NDVI at the district-level, 2002-2013.	MODIS NDVI data from WFP VAM
Price level	Price level at the disaggregation of analytical strata.	SHFS data
Regional and population type controls		
Region x type	Interaction takes the following values: Mogadishu-urban, NE-urban, NE-rural, NW-urban, NW-rural, Central regions - urban, Central regions - rural, Jubbaland-urban, SW-urban, SW-rural.	
Type	Urban, rural indicator.	
Household characteristics		
Household size	Number of members in the household.	
Remittances	Household remittances receipt status (Yes/No).	
Household head age	Age of the household head (years).	
Household head literacy	Literacy of the household head (Yes/No)	
Gender composition	Gender composition of the household (Share of males).	
Dwelling characteristics		
Tenure	Tenure status of household (own, rent, other).	
Dwelling type	Type of the dwelling (Shared, separate, other).	
Roof material	Roof material of the dwelling (Metal sheets, Tiles, Harar, Wood, Plastic, Other).	
Floor material	Floor material of the dwelling (Concrete, Tiles or Mud, Other).	
Improved sanitation	Access to improved sanitation.	
Conflict controls		
Conflict fatalities	Conflict fatalities in district in past 12 month according to ACLED.	ACLED
Conflict x drought	Interaction of drought intensity and conflict fatalities.	ACLED; MODIS NDVI
Assistance controls		

Assistance in region	Percentage of beneficiaries reached through food aid and livelihood inputs in 2017 in region.	Food Security Cluster

Table A.2: Regression results, consumption and poverty, full sample.

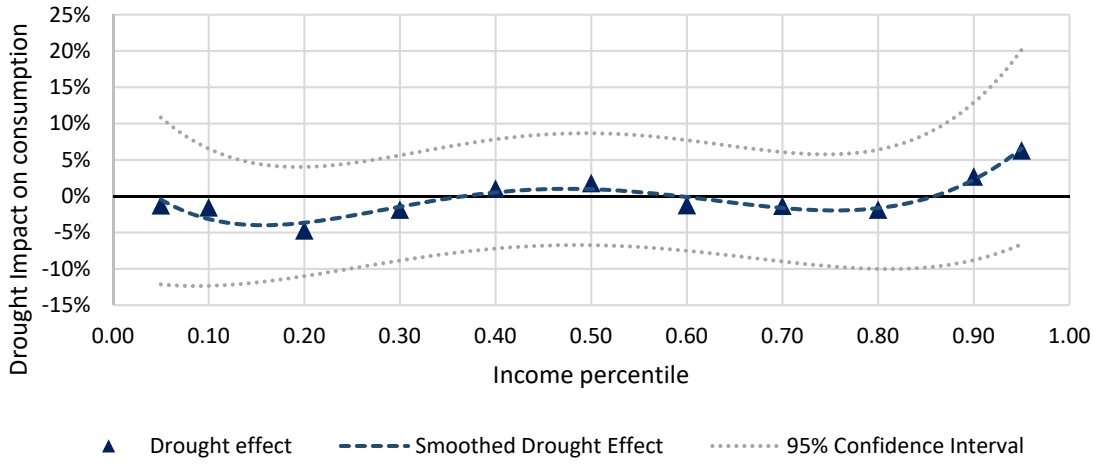
Outcome variable	Consumption			Poverty		
Population	urban + rural	urban	Rural	urban + rural	urban	rural
Post	-0.155***	-0.174***	-0.202***	0.272***	0.357***	0.425***
	(0.036)	(0.036)	(0.051)	(0.051)	(0.063)	(0.076)
Drought Intensity	-0.050**	-0.066***	0.100***	0.068*	0.084*	-0.132***
	(0.024)	(0.024)	(0.029)	(0.040)	(0.045)	(0.050)
Drought Effect	0.000	0.029	-0.146**	-0.005	-0.020	0.264***
	(0.039)	(0.035)	(0.066)	(0.051)	(0.057)	(0.081)
Average NDVI	0.413***	0.170**	0.814**	-0.450***	-0.255*	-0.049
	(0.136)	(0.082)	(0.381)	(0.157)	(0.134)	(0.407)
Price level	-0.192	-0.410**	0.375	0.572***	0.475*	0.411
	(0.165)	(0.164)	(0.399)	(0.167)	(0.245)	(0.386)
Regional controls						
NE-urban	0.051	0.200***			-0.469***	
	(0.077)	(0.072)			(0.101)	
NW-urban	-0.117*	0.001			-0.115	
	(0.069)	(0.055)			(0.082)	
NE-rural	-0.244***					
	(0.067)					
NW-rural	-0.210***		0.124***			0.367***
	(0.076)		(0.042)			(0.076)
Central-urban	0.153**	0.201***			-0.466***	
	(0.066)	(0.072)			(0.112)	
Central-rural	0.205		0.793***			-0.198
	(0.184)		(0.224)			(0.190)
Jubbaland-urban	0.589***	0.484***			-1.127***	
	(0.119)	(0.079)			(0.152)	
SW-urban	0.372***	0.199***			-0.386***	
	(0.101)	(0.070)			(0.127)	
SW-rural	0.282**		1.283***			-0.459
	(0.124)		(0.346)			(0.298)
Household controls						
HH head literacy	0.047***	0.066***	0.011	-0.051*	-0.062*	-0.040
	(0.016)	(0.015)	(0.028)	(0.030)	(0.033)	(0.056)
HH head age	0.001**	0.001	0.002**	-0.001	-0.000	-0.003**
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Received remittances	0.065***	0.073***	0.039	-0.136***	-0.143***	-0.118
	(0.014)	(0.015)	(0.031)	(0.022)	(0.021)	(0.079)
Household size	-0.058***	-0.056***	-0.057***	0.081***	0.084***	0.068***
	(0.003)	(0.003)	(0.008)	(0.005)	(0.005)	(0.017)
Gender composition	0.030	-0.005	0.112*	-0.072	-0.028	-0.195*
	(0.031)	(0.032)	(0.057)	(0.057)	(0.062)	(0.101)
Dwelling controls						
Dwelling tenure: Rent	0.010	0.008	0.023	-0.027	-0.042	0.038
	(0.014)	(0.016)	(0.027)	(0.026)	(0.028)	(0.051)
Dwelling tenure: Other	-0.051*	-0.075**	0.029	0.107**	0.162***	-0.011
	(0.027)	(0.029)	(0.053)	(0.045)	(0.053)	(0.078)

Dwelling floor: Tiles or mud	-0.005	0.025*	-0.192***	-0.018	-0.055*	0.205***
	(0.016)	(0.015)	(0.049)	(0.027)	(0.029)	(0.062)
Dwelling floor: Other	-0.064***	-0.061**	-0.193***	0.044	0.064	0.202***
	(0.023)	(0.024)	(0.043)	(0.037)	(0.040)	(0.075)
Dwelling type: Separate	0.020	0.029	-0.058	-0.034	-0.043	-0.009
	(0.025)	(0.021)	(0.044)	(0.039)	(0.039)	(0.083)
Dwelling type: Other	0.022	0.002	0.069	-0.040	-0.030	-0.083
	(0.021)	(0.018)	(0.042)	(0.031)	(0.030)	(0.087)
Dwelling roof: Tiles	0.015	-0.057	0.529***	0.093	0.155*	-0.227**
	(0.061)	(0.048)	(0.128)	(0.067)	(0.080)	(0.087)
Dwelling roof: Harar	-0.051*	-0.127***	0.035	0.070	0.228***	-0.048
	(0.031)	(0.029)	(0.057)	(0.052)	(0.058)	(0.077)
Dwelling roof: Raar	-0.206***	-0.291***	-0.169	0.160	0.421**	0.083
	(0.079)	(0.082)	(0.122)	(0.142)	(0.190)	(0.184)
Dwelling roof: Wood	-0.038	-0.068**	-0.015	0.100*	0.096	0.201*
	(0.031)	(0.030)	(0.059)	(0.052)	(0.062)	(0.108)
Dwelling roof: Plastic	-0.083**	-0.166***	-0.046	0.038	0.304***	-0.075
	(0.035)	(0.042)	(0.068)	(0.074)	(0.076)	(0.073)
Dwelling roof: Concrete	0.020	0.051	-0.021	0.068	0.072	0.130
	(0.055)	(0.067)	(0.058)	(0.081)	(0.102)	(0.091)
Dwelling roof: Other	-0.133*	-0.106	-0.248*	0.127*	0.072	0.328**
	(0.078)	(0.093)	(0.130)	(0.071)	(0.093)	(0.158)
Improved sanitation	0.019	0.026	0.054	-0.054	-0.085***	-0.033
	(0.025)	(0.030)	(0.036)	(0.037)	(0.033)	(0.074)
Conflict Controls						
Conflict fatalities in district	0.000	-0.000	-0.000	-0.000	-0.000*	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Conflict x drought	0.000	0.000*	-0.001**	-0.000	-0.000	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Assistance						
Asisstance (% of beneficiaries reached)	-0.347***	-0.337***	-0.307***	0.570***	0.581***	0.472***
	(0.050)	(0.040)	(0.062)	(0.078)	(0.075)	(0.107)
Observations	7,214	5,678	1,536	7,214	5,678	1,536
R-squared	0.348	0.347	0.520			

Source: Authors' calculations.

Note: ***p<0.01, **p<0.05, *p<0.1. Standard errors in parentheses. Poverty status results estimated using Probit, Consumption results estimated using OLS. Drought effect expressed in standard deviations of NDVI loss.

Figure A.3: Drought effect along the consumption distribution, urban areas.



Source: Authors' calculations.

Table A.3: Regression results, hunger.

	All regions			Overlapping regions		
Outcome variable	Hunger					
Sample	urban + rural	urban	rural	urban + rural	urban	rural
Post	0.087	0.130**	0.114	0.117***	0.123***	-0.005
	(0.058)	(0.060)	(0.123)	(0.033)	(0.034)	(0.059)
Drought Intensity	-0.050	-0.084*	-0.034	-0.084***	-0.118***	-0.037
	(0.039)	(0.048)	(0.060)	(0.032)	(0.044)	(0.031)
Drought Effect	0.092**	0.096*	0.190**	0.161***	0.116***	0.588***
	(0.045)	(0.055)	(0.079)	(0.038)	(0.038)	(0.134)
Average NDVI	0.034	-0.092	0.964**	-0.573*	-0.680**	-0.286
	(0.144)	(0.153)	(0.446)	(0.318)	(0.302)	(0.309)
Regional controls						
NE-urban		-0.030				
		(0.083)				
NW-urban		-0.225***			-0.098	
		(0.067)			(0.084)	
NE-rural						
NW-rural			-0.336**			
			(0.135)			
Central-urban		-0.015				
		(0.095)				
Central-rural			0.329			
			(0.233)			
Jubbaland-urban		-0.127				
		(0.176)				
SW-urban		-0.149				
		(0.128)				
SW-rural			0.213			
			(0.352)			
Household controls						
HH head literacy	-0.051**	-0.032	-0.119**	-0.027	-0.017	-0.137***
	(0.024)	(0.026)	(0.058)	(0.026)	(0.027)	(0.038)

HH head age	-0.001	-0.001*	0.002	-0.001	-0.001	0.000
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Received remittances	-0.002	-0.033	0.170***	-0.020	-0.033	-0.015
	(0.024)	(0.025)	(0.044)	(0.024)	(0.025)	(0.021)
Household size	-0.006	-0.001	-0.021	-0.012**	-0.009	-0.007
	(0.006)	(0.005)	(0.017)	(0.005)	(0.005)	(0.009)
Gender composition	-0.003	0.024	-0.019	-0.007	0.012	0.010
	(0.051)	(0.051)	(0.130)	(0.048)	(0.054)	(0.033)
Dwelling controls						
Dwelling tenure: Rent	0.029	0.018	0.074	0.004	0.013	-0.101***
	(0.022)	(0.020)	(0.065)	(0.020)	(0.019)	(0.028)
Dwelling tenure: Other	0.212***	0.116*	0.246**	0.153*	0.109*	0.024
	(0.070)	(0.060)	(0.112)	(0.079)	(0.063)	(0.079)
Dwelling floor: Tiles or mud	-0.010	-0.016	0.036	-0.010	-0.006	0.106**
	(0.031)	(0.030)	(0.082)	(0.028)	(0.030)	(0.042)
Dwelling floor: Other	0.003	0.051	-0.027	0.058	0.053	0.124**
	(0.041)	(0.038)	(0.087)	(0.042)	(0.043)	(0.051)
Dwelling type: Separate	-0.068	-0.087*	-0.063	-0.056	-0.085**	0.156**
	(0.054)	(0.050)	(0.100)	(0.034)	(0.036)	(0.066)
Dwelling type: Other	-0.036	-0.026	-0.130*	-0.036	-0.030	0.065
	(0.044)	(0.037)	(0.071)	(0.031)	(0.028)	(0.054)
Dwelling roof: Tiles	0.036	-0.001	0.296**	-0.143***	-0.216**	
	(0.126)	(0.125)	(0.114)	(0.034)	(0.089)	
Dwelling roof: Harar	0.130**	0.174***	0.140*	0.065	0.093	0.047
	(0.058)	(0.060)	(0.076)	(0.057)	(0.061)	(0.049)
Dwelling roof: Raar	0.070	0.099	0.120*	-0.052	0.006	0.056
	(0.068)	(0.077)	(0.067)	(0.046)	(0.072)	(0.064)
Dwelling roof: Wood	-0.059	-0.042	-0.109	-0.077*	-0.097	-0.007
	(0.064)	(0.079)	(0.146)	(0.046)	(0.072)	(0.055)
Dwelling roof: Plastic	0.091	0.076	0.124	-0.004	0.048	-0.052
	(0.063)	(0.092)	(0.075)	(0.065)	(0.086)	(0.058)
Dwelling roof: Concrete	-0.053	-0.033	-0.228			
	(0.104)	(0.119)	(0.148)			
Dwelling roof: Other	0.075	-0.000	0.161	-0.010	-0.019	-0.020
	(0.077)	(0.083)	(0.109)	(0.060)	(0.074)	(0.078)
Improved sanitation	-0.002	0.015	-0.043	-0.031	-0.045	0.013
	(0.039)	(0.043)	(0.052)	(0.030)	(0.031)	(0.035)
Conflict fatalities in district	0.000	0.000	0.001***			
	(0.000)	(0.000)	(0.000)			
Conflict x drought	-0.000	-0.000	-0.000			
	(0.000)	(0.000)	(0.000)			
Assistance (% of beneficiaries reached)	-0.052	-0.191**	0.198	0.078	-0.010	0.039
	(0.094)	(0.094)	(0.122)	(0.068)	(0.099)	(0.055)
Observations	7,153	5,637	1,516	3,962	3,292	663

Source: Authors' calculations.

Note: ***p<0.01, **p<0.05, *p<0.1. Standard errors in parentheses. Results estimated with Probit. Drought effect expressed in standard deviations of NDVI loss.

Table A.4: Regression results, food consumption.

	All regions			Overlapping regions		
Outcome variable	Food Consumption					
Sample	urban + rural	urban	rural	urban + rural	urban	rural
Post	-0.069**	-0.080**	-0.182***	-0.049	-0.020	-0.230***
	(0.033)	(0.036)	(0.051)	(0.033)	(0.044)	(0.053)
Drought Intensity	-0.013	-0.017	0.091***	0.000	-0.016	0.068
	(0.018)	(0.020)	(0.030)	(0.017)	(0.020)	(0.042)
Drought Effect	-0.026	-0.024	-0.110**	0.006	0.033	-0.105**
	(0.031)	(0.033)	(0.054)	(0.028)	(0.039)	(0.043)
Average NDVI	0.362***	0.179**	0.737**	0.145	0.153	-0.338
	(0.120)	(0.087)	(0.342)	(0.163)	(0.168)	(0.313)
Price level	0.034	-0.293	0.501	0.164	0.394**	0.113
	(0.160)	(0.265)	(0.326)	(0.160)	(0.181)	(0.224)
Regional controls						
NE-urban	-0.003	0.155*				
	(0.080)	(0.089)				
NW-urban	-0.036	0.125*		0.071	-0.032	
	(0.062)	(0.075)		(0.055)	(0.060)	
NE-rural	-0.440***					
	(0.055)					
NW-rural	-0.074		0.345***	0.066		
	(0.065)		(0.058)	(0.065)		
Central-urban	0.201***	0.311***				
	(0.075)	(0.104)				
Central-rural	0.210		0.918***			
	(0.147)		(0.177)			
Jubbaland-urban	0.393***	0.375***				
	(0.099)	(0.101)				
SW-urban	0.293***	0.260**				
	(0.092)	(0.108)				
SW-rural	0.240**		1.204***			
	(0.102)		(0.331)			
Household controls						
HH head literacy	0.032**	0.054***	-0.001	0.054***	0.058***	0.031
	(0.013)	(0.011)	(0.024)	(0.013)	(0.014)	(0.042)
HH head age	0.001	0.000	0.002**	0.001	0.000	0.003**
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Received remittances	0.038***	0.046***	0.002	0.049***	0.056***	-0.047*
	(0.014)	(0.016)	(0.026)	(0.016)	(0.017)	(0.028)
Household size	-0.048***	-0.046***	-0.049***	-0.047***	-0.044***	-0.071***
	(0.002)	(0.003)	(0.007)	(0.003)	(0.002)	(0.009)
Gender composition	0.006	-0.035	0.110*	-0.014	-0.031	0.051
	(0.032)	(0.028)	(0.058)	(0.029)	(0.032)	(0.062)
Dwelling controls						
Dwelling tenure: Rent	0.010	0.004	0.015	0.010	0.009	0.009
	(0.012)	(0.013)	(0.023)	(0.015)	(0.016)	(0.028)
Dwelling tenure: Other	-0.043*	-0.060**	0.023	-0.022	-0.038	0.187***
	(0.024)	(0.028)	(0.041)	(0.031)	(0.030)	(0.068)
Dwelling floor: Tiles or mud	-0.003	0.019	-0.114***	-0.001	0.018	-0.223***

	(0.016)	(0.016)	(0.042)	(0.018)	(0.018)	(0.057)
Dwelling floor: Other	-0.033*	-0.017	-0.128***	-0.048**	-0.054**	-0.218***
	(0.020)	(0.023)	(0.038)	(0.023)	(0.026)	(0.060)
Dwelling type: Separate	0.015	0.015	-0.091**	-0.011	-0.002	-0.055
	(0.019)	(0.017)	(0.037)	(0.018)	(0.018)	(0.060)
Dwelling type: Other	0.019	0.002	0.019	-0.012	-0.012	-0.010
	(0.018)	(0.016)	(0.030)	(0.017)	(0.017)	(0.060)
Dwelling roof: Tiles	0.045	-0.006	0.295***	-0.018	-0.035	0.364***
	(0.046)	(0.037)	(0.073)	(0.043)	(0.043)	(0.094)
Dwelling roof: Harar	-0.033	-0.077***	0.015	-0.026	-0.081***	0.144*
	(0.026)	(0.028)	(0.055)	(0.033)	(0.029)	(0.080)
Dwelling roof: Raar	-0.168***	-0.204***	-0.126	-0.158	-0.268***	0.038
	(0.064)	(0.054)	(0.093)	(0.106)	(0.044)	(0.130)
Dwelling roof: Wood	0.026	0.011	0.024	-0.008	0.004	-0.003
	(0.028)	(0.031)	(0.050)	(0.033)	(0.033)	(0.090)
Dwelling roof: Plastic	-0.027	-0.097**	-0.016	-0.082*	-0.116***	0.090
	(0.030)	(0.038)	(0.052)	(0.043)	(0.038)	(0.077)
Dwelling roof: Concrete	0.064**	0.097***	-0.062	0.046	0.090***	-0.065
	(0.027)	(0.035)	(0.075)	(0.041)	(0.028)	(0.095)
Dwelling roof: Other	-0.068	-0.063	-0.161	-0.053	-0.047	0.028
	(0.073)	(0.090)	(0.111)	(0.072)	(0.087)	(0.107)
Improved sanitation	0.003	-0.000	0.039	-0.022	-0.025	0.013
	(0.027)	(0.036)	(0.032)	(0.033)	(0.040)	(0.046)
Conflict fatalities in district	-0.000**	-0.000**	-0.000**	-0.000**	-0.000***	-0.013
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.008)
Conflict x drought	0.000	0.000	-0.000*	0.000***	0.000***	-0.002
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.007)
Asisstance (% of beneficiaries reached)	-0.197***	-0.232***	-0.240***	-0.186***	-0.174***	-0.078
	(0.035)	(0.041)	(0.081)	(0.035)	(0.034)	(0.081)
Observations	7,214	5,678	1,536	4,044	3,348	696
R-squared	0.347	0.304	0.591	0.297	0.312	0.461

Source: Authors' calculations.

Note: ***p<0.01, **p<0.05, *p<0.1. Standard errors in parentheses. Results estimated with OLS. Drought effect expressed in standard deviations of NDVI loss.

Table A.5: Regression results, consumption and poverty, overlapping sample.

Outcome variable	Consumption			Poverty		
Sample	urban + rural	urban	Rural	urban + rural	urban	rural
Post	-0.223***	-0.241***	-0.237***	0.454***	0.386***	0.570***
	(0.040)	(0.047)	(0.064)	(0.093)	(0.116)	(0.080)
Drought Intensity	-0.045**	-0.079***	0.047	0.046	0.111***	-0.046
	(0.020)	(0.022)	(0.041)	(0.033)	(0.040)	(0.076)

Drought Effect	-0.045	-0.033	-0.137**	0.141*	0.021	0.356***
	(0.039)	(0.041)	(0.055)	(0.081)	(0.101)	(0.090)
Average NDVI	-0.055	-0.064	-0.490	-0.247	-0.383	1.040
	(0.163)	(0.157)	(0.426)	(0.373)	(0.369)	(0.778)
Regional controls						
NW-urban	0.155*	0.124			-0.049	
	(0.079)	(0.083)			(0.187)	
NE-rural						
NW-rural	0.090					
	(0.097)					
Household controls						
HH head literacy	0.078***	0.081***	0.044	-0.092***	-0.078**	-0.145***
	(0.014)	(0.014)	(0.050)	(0.030)	(0.032)	(0.044)
HH head age	0.001	0.000	0.003*	-0.001	0.000	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Received remittances	0.073***	0.076***	-0.029	-0.138***	-0.145***	-0.091
	(0.015)	(0.016)	(0.042)	(0.024)	(0.026)	(0.056)
Household size	-0.058***	-0.056***	-0.078***	0.084***	0.080***	0.136***
	(0.003)	(0.003)	(0.010)	(0.005)	(0.005)	(0.012)
Gender composition	0.012	0.000	0.040	-0.057	-0.023	-0.198***
	(0.033)	(0.036)	(0.075)	(0.067)	(0.069)	(0.071)
Dwelling controls						
Dwelling tenure: Rent	-0.001	0.000	0.035	-0.005	-0.022	0.063
	(0.016)	(0.015)	(0.028)	(0.024)	(0.023)	(0.048)
Dwelling tenure: Other	-0.051	-0.065*	0.198***	0.076	0.114**	-0.246**
	(0.034)	(0.036)	(0.069)	(0.050)	(0.053)	(0.119)
Dwelling floor: Tiles or mud	0.012	0.044**	-0.283***	-0.024	-0.057*	0.259***
	(0.020)	(0.018)	(0.070)	(0.032)	(0.033)	(0.061)
Dwelling floor: Other	-0.064***	-0.082***	-0.223***	0.081**	0.145***	0.141
	(0.024)	(0.026)	(0.073)	(0.039)	(0.043)	(0.085)
Dwelling type: Separate	0.009	0.016	-0.025	-0.017	-0.028	-0.000
	(0.020)	(0.020)	(0.070)	(0.041)	(0.042)	(0.069)
Dwelling type: Other	-0.007	-0.010	0.058	-0.030	-0.033	0.005
	(0.019)	(0.019)	(0.079)	(0.029)	(0.029)	(0.072)
Dwelling roof: Tiles	-0.061	-0.079	0.377***	0.159**	0.196**	-0.206
	(0.049)	(0.051)	(0.104)	(0.068)	(0.080)	(0.157)
Dwelling roof: Harar	-0.044	-0.117***	0.160	0.107**	0.194***	-0.063
	(0.036)	(0.033)	(0.098)	(0.052)	(0.061)	(0.062)
Dwelling roof: Raar	-0.213*	-0.364***	0.035	0.245	0.730***	-0.007
	(0.117)	(0.066)	(0.176)	(0.170)	(0.091)	(0.161)
Dwelling roof: Wood	-0.084**	-0.074**	-0.041	0.152***	0.124*	0.297**
	(0.034)	(0.031)	(0.104)	(0.052)	(0.064)	(0.116)
Dwelling roof: Plastic	-0.132***	-0.179***	0.103	0.203***	0.292***	-0.089
	(0.049)	(0.044)	(0.096)	(0.061)	(0.079)	(0.089)
Dwelling roof: Concrete	0.036	0.091	-0.033	0.082	0.044	0.075

	(0.064)	(0.061)	(0.121)	(0.072)	(0.081)	(0.157)
Dwelling roof:						
Other	-0.115	-0.091	-0.041	0.127*	0.062	0.100
	(0.078)	(0.092)	(0.118)	(0.075)	(0.094)	(0.122)
Improved sanitation	0.025	0.017	0.059	-0.058	-0.055	-0.064
	(0.027)	(0.034)	(0.050)	(0.039)	(0.035)	(0.070)
Conflict fatalities in district	0.000	0.000	-0.012	-0.000***	-0.000*	0.003
	(0.000)	(0.000)	(0.009)	(0.000)	(0.000)	(0.009)
Conflict x drought	0.000*	0.000*	-0.001	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.007)	(0.000)	(0.000)	(0.011)
Asisstance (% of beneficiaries reached)	-0.207***	-0.219***	-0.125	0.371***	0.407***	0.076
	(0.046)	(0.036)	(0.091)	(0.093)	(0.086)	(0.122)
Observations	4,044	3,348	696	4,044	3,348	696
R-squared	0.332	0.349	0.474			

Source: Authors' calculations.

Note: ***p<0.01, **p<0.05, *p<0.1. Standard errors in parentheses. Poverty status results estimated using Probit, Consumption results estimated using OLS. Drought effect expressed in standard deviations of NDVI loss.