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SPECIAL ISSUE ARTICLE

Climate change-related shocks, assets and welfare outcomes in South Africa

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Abstract

Climate change and its consequences pose significant economic and social challenges around the world. Droughts have frequently afflicted South Africa, with the most recent severe drought occurring in 2015/2016. However, there has been little empirical research estimating the impact of climate-related shocks on individual well-being in South Africa. In this paper, we investigate the impact of the 2015/2016 drought on individual welfare. We also examine whether access to assets helps to mitigate the negative effects of climate change-related shocks on individual welfare. For estimating the impact of droughts on individual welfare outcomes, weather data are combined with individual panel data from the National Income Dynamics Study dataset. We use weather data from meteorological satellites to measure the extent of droughts across the country, and we measure individual welfare using real per capita consumption expenditure. Our estimation results show that the 2015/2016 drought had no significant effect on real per capita consumption expenditure in South Africa. We hypothesise that this is due in part to the structure of the labour market, with few people relying on subsistence farming, combined with social grants and remittances being the primary source of income for people at the bottom of the consumption distribution. Using anthropometric measurements as an alternative welfare indicator, we find that children living in drought-affected areas had lower weight-for-height measurements than those living in areas not affected by the drought. The findings imply that when food prices increased as a result of the drought, households may have chosen welfare-costly coping techniques such as reducing the quantity and quality of food consumed while keeping overall expenditure the same.

KEYWORDS

assets, climate change shocks, South Africa, well-being

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1 | INTRODUCTION

Climate change and its consequences are associated with substantial negative social and environmental consequences worldwide, which are expected to continue for the foreseeable future, thus increasing the risk of poverty and food insecurity (FAO, 2022). South Africa is one of the countries that experienced frequent climate-related shocks, including droughts, in recent decades (see Meza et al., 2021).[1] Among these, the 2015–2016 drought was one of the most severe in recent years, resulting in adverse socio-economic consequences (see Ruwanza et al., 2022; Schreiner et al., 2018).

Climate change-related shocks can reduce household welfare through a variety of channels, including decreased agricultural and non-agricultural output and employment, increased food prices and increased livestock input prices (Bimal, 1998; Schreiner et al., 2018). For instance, the 2015–2016 drought in South Africa was associated with large declines in agricultural production, with agriculture gross value added falling by more than 15% in major crop producing provinces such as Free State and Northwest (Stats SA, 2020). Furthermore, Schreiner et al. (2018) demonstrated that drought-induced water shortages reduced crop and livestock production, as well as employment and production in non-agricultural sectors in South Africa.

Previous research shows that in the face of climate-related or other shocks, households use a variety of ex ante and ex post coping mechanisms, including livelihood and crop diversification, migration and the sale of productive assets such as livestock and land (Gebrehiwot et al., 2021; Janzen & Carter, 2019). However, access to resources may limit poor and vulnerable households' ability to cope and adapt to climate-related shocks. Existing evidence, for example, suggests that assets are critical in mitigating the negative effects of climate change-related shocks (Kodwo-Ansah et al., 2021; Prowse & Scott, 2008). As a result, the extent to which climate-related shocks affect individual welfare outcomes is a function of several factors, including individuals' coping capacity, access to insurance and social safety nets and government responses to the challenge.

In this paper, we analyse the effect of the 2015/2016 drought on individual welfare in South Africa and whether having access to assets helps in mitigating the negative effects of climate change-related shocks on individual welfare. There has been limited empirical research undertaken in South Africa to estimate the impact of climate-related shocks on individual well-being (see Ruwanza et al., 2022). The few studies that look at the impact of climate change-related shocks on individual well-being outcomes in South Africa are mostly limited to specific regions of the country and rely heavily on qualitative approaches. In this paper, we use survey data from the National Income Dynamics Study (NIDS) dataset, which is a nationally representative individual panel dataset. We evaluate the impact of the 2015/2016 drought on individual welfare by combining weather data from meteorological satellites with the NIDS dataset. In this paper, individual welfare is measured using real per capita consumption expenditure. Also, we use anthropometric data as an alternative welfare indicator.

The paper is organised as follows: In Section 2, we present a brief review of the literature that serves as a framework for understanding the impact of climate change-related shocks on wellbeing outcomes. Section 3 describes the datasets and methods for measuring climate-related shocks, as well as the empirical strategy for estimating the impact of the 2015/2016 drought on individual welfare. Section 4 provides estimation results. Section 5 provides summary of the main findings.

2 | CONCEPTUAL FRAMEWORK

Climate change-related shocks can manifest themselves in a variety of ways, depending on the type of shock, the length of the shock and the geographic spread of the shock. In this research, we examine the

[1]Major drought events were recorded in 1982–1984, 1991–1992, 1994–1995, 2004–2005, 2008–2009, 2015–2016 and 2018–2020 (see Meza et al., 2021).

impact of one of these shocks, the 2015/2016 drought in South Africa, which was considered one of the worst in recent years. Droughts can adversely affect individual welfare through a variety of channels (Figure 1). One of the direct mechanisms would be a decrease in household income due to a decrease in agricultural production and the loss of assets (e.g. livestock). The combined impact of these impacts for residents of the impacted areas would suggest an increase in food and livestock input costs, as well as potential job losses. Furthermore, drought-induced water shortages can have an impact on business activity in non-agricultural sectors, resulting in employment and income losses. Business activities that rely heavily on agricultural output processing are particularly vulnerable (Schreiner et al., 2018).

The extent to which climate-related shocks, such as droughts, negatively affect individual welfare outcomes is affected by individuals' mitigating and coping capacities. Lack of access to financial and non-financial resources, insurance and social safety nets may hinder poor and vulnerable households' ability to cope and adapt to adverse climate change-related shocks (Janzen & Carter, 2019; Winsemius et al., 2018). Existing evidence, for example, suggests that assets are crucial in buffering the negative effects of climate change-related shocks in various contexts (Kodwo-Ansah et al., 2021; Prowse & Scott, 2008).

Although droughts can harm some income-generating assets possessed by households (e.g. by reducing the quantity of livestock), climate change-related shocks do not always affect all type of assets. For example, a distressed sale of assets such as livestock during a drought may diminish asset values and

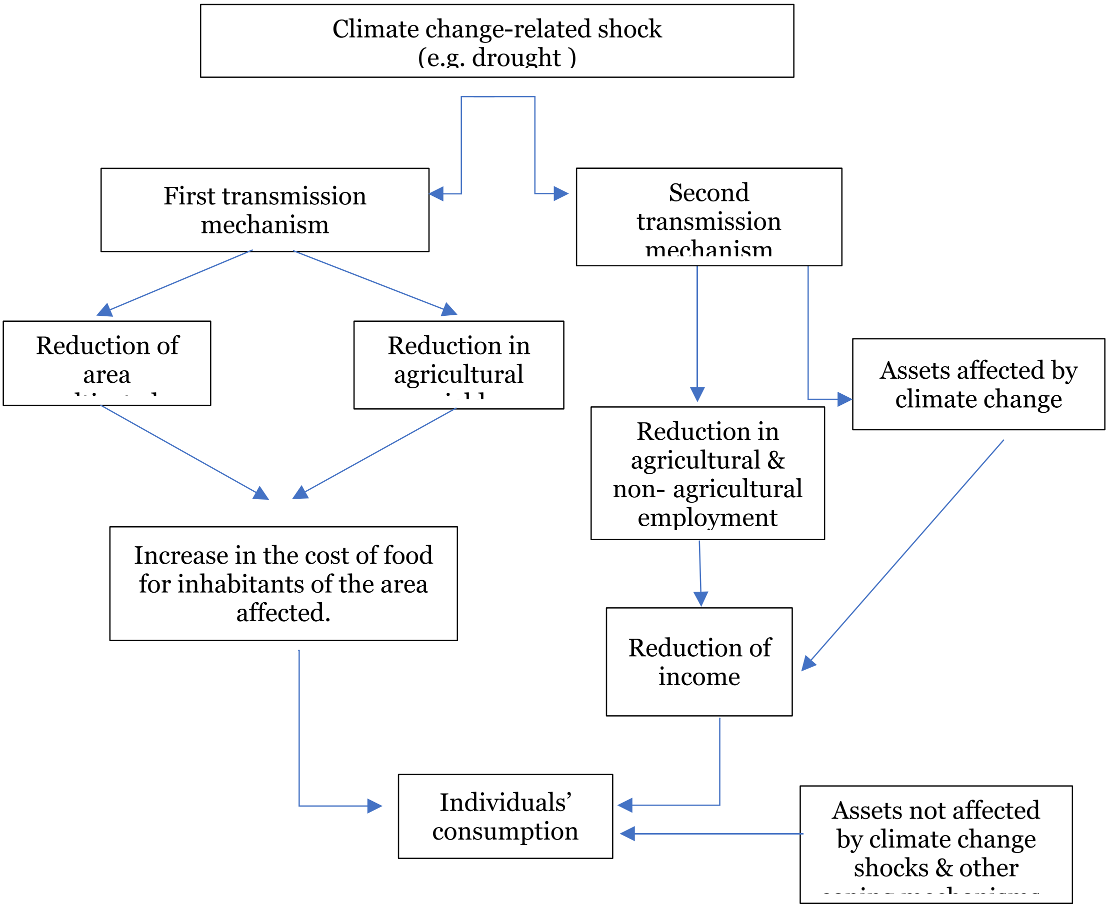

FIGURE 1 Illustration of the multiple impacts of a climate change-related shock. *Source*: Adapted from (Bimal, 1998).

income. We anticipate, however, that drought-induced distress sales may have large price effects mainly on livestock sales. This is especially true in economies where a large section of the population relies on subsistence farming or livestock farming, as droughts can have a direct impact on livestock survival. In the case of South Africa, livestock constitutes a very small share of total asset values (see Daniels & Augustine, 2016). Other kind of assets, such as financial assets, are expected to be less susceptible to the price effects of a drought. Those assets (e.g. financial assets, land and real estate assets and vehicles) can be useful in consumption smoothing against the effects of climatic shocks, and households with more assets are likely to be more resilient (Kodwo-Ansah et al., 2021).

South Africa does not only have an unequal income distribution but also very high inequality in the distribution of assets and wealth (see Figure A1 in Appendix S1), with the share of wealth among the poorest 50% of the population being very small. As a result, existing inequities in the distribution of assets and wealth might be translated into inequalities in households' coping capacity in the face of climate-related or other shocks. We hypothesise that climate change-related shocks such as droughts reduce household welfare but that this impact is lower for households with access to assets than for households with limited access to assets.

The impact of climate change-related shocks on individual welfare varies across countries and contexts, depending on the nature of the labour market and other factors. In the context of South Africa, existing evidence indicates that drought-induced water constraints reduced crop and livestock production, as well as employment and production in non-agricultural industries (see Schreiner et al., 2018). However, subsistence farming employs between 4% and 6% of South African households. As a result, we anticipate that the primary channel through which drought may affect individual well-being is an increase in the cost of food and inputs, or the loss of employment in agricultural and related non-agricultural industries. However, the effects of the drought will be mitigated as a result of access to social grants by the poor. In our empirical analysis, we investigate the impact of the 2015/2016 drought on individual welfare after controlling for access to social grants and other individual and household characteristics.

3 | METHODOLOGY AND MEASUREMENT

3.1 | Data sources

For individual and household level socio-economic data, we use data from the NIDS dataset. NIDS is a nationally representative individual panel survey implemented across five different waves (Brophy et al., 2018). The NIDS survey began in 2008 (wave 1) by interviewing 28,226 individuals living in 7,296 households, and additional waves were conducted in 2010 (wave 2), 2012 (wave 3), 2015 (wave 4) and 2017 (wave 5). The survey collects information on a variety of topics, including demographic and housing characteristics, food and non-food consumption expenditure, income and sources of income and individual and household wealth. Data on physical assets and wealth were only collected during waves 2, 4 and 5, and we only use these three waves in this paper. We limited our sample to individuals who were present during the three waves. We have 12,402 adult individuals who have complete information from all three waves.

There is no information on self-reported experiences of climate-related shocks in the NIDS data. However, NIDS provides GPS locations of individuals' households in secure versions of the data. This data is combined with weather data from meteorological satellites to measure climate-related shocks such as droughts and floods. Weather data are accessible with a spatial resolution of 50 × 50 km from the Global SPEI database[2] and the World Meteorological Organization (WMO).[3]

[2]https://spei.csic.es/

[3]https://climexp.knmi.nl/start.cgi

3.2 | Individual welfare and wealth

The outcome of interest in this paper is real per capita consumption expenditure. NIDS collected detailed information on household consumption expenditures on food and non-food items in the 30 days preceding each survey round. Individuals' per capita consumption is calculated by dividing total household consumption by total household size.

The wealth module in the NIDS dataset collects information on the value of individual and household asset holdings, as well as debt and liabilities. Our household asset measure is the total asset value measured at the household level. The asset portfolios used to estimate total assets in wave 5 are the same as in wave 4, and they consist of the sum of real estate assets (including houses and other properties), business assets, vehicles, financial assets (including a bank account and stocks), retirement annuities, livestock value and household durable assets (or household possessions such as having a TV, washing machine, etc.). However, due to the poor quality of the data, estimates of household durable assets were not included in the total asset computation in wave 2 (Daniels & Augustine, 2016). To be consistent, we created a wealth variable by subtracting the value of household consumer durables from total asset values in wave 4 and wave 5.[4] The distribution of real per capita consumption expenditure and wealth are shown in Figure A1 in Appendix S1. Real values of per capita consumption expenditure and wealth are calculated using the 2015 prices.

In addition to the per capita consumption measure, we use anthropometric measurements such as weight-for height (WHZ) and height-for-age (HAZ) Z-scores for children aged between 1 and 5 years old during the 2017 survey as alternative welfare indicators.

3.3 | Climate change shocks

The literature presents several ways of measuring climate-related shocks such as landslides, droughts, floods or heat waves. One approach is to ask households whether they expect or experienced climate-related shocks or not. An alternative approach is to use meteorological data such as rain anomalies or vegetation anomalies to measure or predict climate-related shocks in a given area.

We use climate variability to measure the occurrence of climate-related shocks such as droughts and floods. One way of measuring a climate-related shock is to use the precipitation or temperature data to calculate the standardised deviation of a particular year from the historical average preceding that year (e.g. Gebrehiwot et al., 2021; Makate et al., 2022). Thus, based on precipitation data, negative values indicate below-average precipitation, and positive values indicate above-average precipitation. In addition to using rainfall and temperature data, various indices have been used to identify climate-related shocks such as droughts and floods (see, e.g. Edossa et al., 2014). Among the most widely used indicators is the Standardised Precipitation Index (SPI), which was developed by McKee et al. (1993).

Another commonly used index is the Standardised Precipitation-Evapotranspiration Index (SPEI), developed by Vicente-Serrano et al. (2010). While the SPI is calculated based on long-term precipitation data, the SPEI is calculated based on both precipitation and potential evapotranspiration data. Thus, by incorporating temperature data, the SPEI is a better measure for measuring drought conditions. The SPEI can be calculated across different time scales, for example, 6 months (SPEI-06), 12 months (SPEI_12) or 24 months (SPEI_24). While shorter time scales indicate a high frequency of a shock (i.e. drought and short-term moist periods), longer time scales indicate longer-duration of shocks. In this paper, we use the SPEI_12 indices and calculated annual averages of the monthly SPEI estimates for square areas of 50×50 km in South Africa.[5]

[4]In the case of households with zero wealth values, we assigned a small value (a value of one ZAR was assigned to all households with zero wealth values) to keep these households in the analysis.

[5]The use of SPEI index allows us to measure only droughts and floodings. Thus, other types of climate-related shocks such as wildfires and storms are not considered.

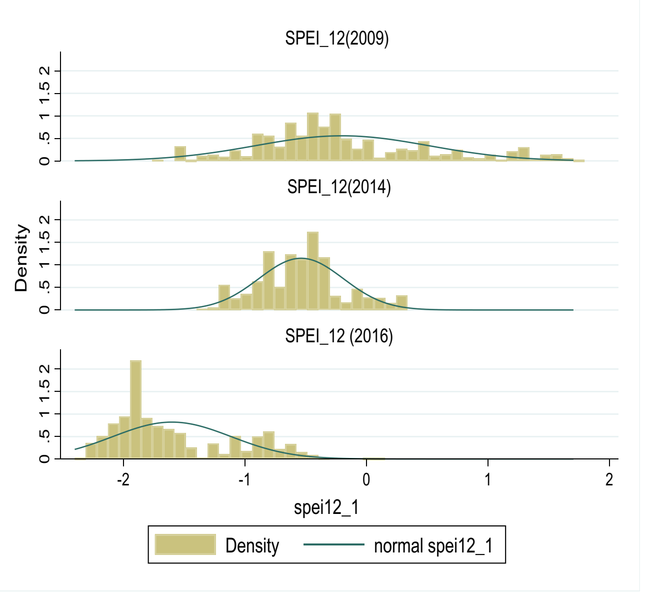

FIGURE 2 The distribution of estimates of SPEI-12 in 2009, 2014 and 2016. *Source*: Authors' estimates using data from WMO and NIDS.

Figure 2 displays the distribution of SPEI_12 estimates for 2009, 2014 and 2016 (1 year ahead of each household survey year), suggesting that large share of individuals experienced drought in 2016, but no flooding. This is consistent with recent research, which found that 2015 and 2016 were two of the driest years in recent years in South Africa (Meza et al., 2021).

The SPEI is a standardised variable with mean zero and standard deviation value of 1, and the SPEI value often ranges from −5 to +5. Higher negative values associated with drought events, while higher positive values associated with flooding events. Table A1 in Appendix S1 shows the commonly used threshold values to categorise drought and flood conditions based on the SPEI estimates. Based on the SPEI index, we generated a variable that indicated the occurrence of severe, or extreme drought (SPEI < = − 1.5). We tested the sensitivity of our estimations for a slightly different SPEI cut-off point (SPEI < = − 2), which indicates extreme drought events.

Table 1 illustrates that at the national level, 7.3% of individuals lived in drought-affected areas in 2015, and this number climbed to 66% in 2016. Looking at the distribution among provinces, the percentage of individuals who experienced severe or extreme drought in 2016 was greater than 50% in all provinces except KwaZulu-Natal. However, the severity of the drought in KwaZulu-Natal in 2016 varies by region (see Blamey et al., 2018). In 2015, drought conditions were experienced by at least 50% of individuals only in the Western Cape and Northwest provinces. When only extreme drought occurrences were considered (SPEI < = − 2), 18% of people lived in an area that experienced extreme drought in 2015 or 2016 (or both).

3.4 | Empirical strategy

In order to estimate the effect of the 2015/2016 drought on individual welfare outcomes, we specify the following regression model:

$$Y_{it} = \mu + \alpha_i + \psi_t + \delta D_{it} + X_{it}\beta + e_{it} \tag{1}$$

TABLE 1 Percentage of individuals who experienced drought by province in 2015/2016.

	Severe or extreme drought (SPEI < = − 1.5)			Extreme drought (SPEI < = − 2)
	2015	**2016**	**Either 2015 or 2016 (or both)**	**Either 2015 or 2016 (or both)**
National	**7.3**	**65.7**	**65.8**	**18.4**
Western Cape	84.3	97.9	98	0.8
Eastern Cape	0	97.3	97.3	23.4
Northern Cape	9.6	49.5	52.4	7.2
Free State	22.5	100	100	81.8
KwaZulu-Natal	0	7	7	1.2
North West	54.7	96.5	96.5	43.5
Gauteng	2.4	100	100	7.4
Mpumalanga	0	73.4	73.4	28.9
Limpopo	1	95.2	95.2	39.6

Source: Authors' estimates using data from WMO and NIDS.

where Y_{it} indicates the log of real per capita consumption of individual i at time t, α_i captures time invariant individual heterogeneity, ψ_t is a time dummy, X_{it} indicates a vector of household and individual level controls, e_{it} is the error term, D_{it} is a binary variable equal to 1 if individuals experienced drought in 2015/2016 (i.e. the SPEI index value is less than or equal to -1.5) and 0 otherwise and μ is a constant term. The δ captures the impact of the drought on consumption.

We estimate Equation (1) using a simple pooled OLS regression (ignoring α_i). Although climate change shocks are assumed to be exogenous, variables such as asset ownership and access to social grants can be endogenous. For instance, the wealth variable may be correlated with unobservable components that are not included in the regression equation. We use fixed effects (FE) estimation approach to remove time-invariant individual random effects. The variables in X_{it} include individual-level characteristics (age and race), household-level characteristics (head gender, education, employment status, number of dependents, social grants, wealth) and location (rural/urban, province). Table A2 in Appendix S1 shows that individuals who lived in drought affected areas and those who did not had very similar characteristics, with few exceptions. Those who lived in areas that were not affected by the 2015/2016 drought had slightly lower consumption levels, had slightly higher share of individuals with access to social grants and were less likely to live in urban areas.

4 | RESULTS AND DISCUSSION

In Table 2, we begin by presenting estimation results based on the pooled OLS regression analysis for various regression model specifications based on Equation (1). Columns (1) and (2) provide estimates without and with controls, respectively. Columns (3) and (4) provide estimates after controlling for the wealth variable and the interaction of the wealth and the drought variables, respectively. The estimation results show that once individual- and household-level characteristics are controlled for, there is no significant effect of the 2015/2016 drought on individual consumption outcomes. The coefficient estimate for the drought variable has a negative sign only in column (4), although this coefficient estimate is not statistically significant.

The coefficient estimates for the wealth variable in columns (3) and (4) are positive and statistically significant, indicating that consumption is relatively higher for wealthier individuals. The coefficient estimate for the interaction term in column (4), however, is small and not significantly different from zero, indicating that the effect of the 2015/2016 drought on consumption does not vary by individuals' wealth status. In terms of the other control variables, per capita consumption is higher in urban areas than in

TABLE 2 The effect of the 2015/2016 drought on individuals' welfare (pooled OLS).

	(1)	(2)	(3)	(4)
Drought	0.374***	0.0175	0.0155	−0.0582
	(0.083)	(0.036)	(0.034)	(0.056)
Wealth (log)			0.0471***	0.0456***
			(0.003)	(0.003)
Drought × Wealth				0.00723
				(0.005)
Time dummy	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes
_cons	6.305***	5.923***	5.779***	5.794***
	(0.048)	(0.070)	(0.069)	(0.070)
N	12,402	12,402	12,402	12,402
NT	37,206	37,206	37,206	37,206
Adj. R^2	0.041	0.429	0.454	0.454

Notes: Standard errors in parentheses. Standard errors clustered at the pixel ID level.
Source: Authors' estimates using data from WMO and NIDS.

TABLE 3 The effect of the 2015/2016 drought on individuals' welfare (FE).

	(1)	(2)	(3)	(4)
Drought	0.0385**	0.00431	0.00210	0.0642*
	(0.0143)	(0.0130)	(0.0129)	(0.0282)
Wealth (log)			0.0178***	0.0190***
			(0.00127)	(0.00138)
Drought × Wealth				−0.00610*
				(0.00248)
Time dummy	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes
_cons	6.305***	8.702***	8.537***	8.525***
	(0.00542)	(0.416)	(0.418)	(0.418)
N	12,402	12,402	12,402	12,402
NT	37,206	37,206	37,206	37,206
Adj. R^2	0.103	0.245	0.251	0.251

Note: Standard errors in parentheses.
Source: Authors' estimates using data from WMO and NIDS.

rural areas. Living in a male-headed household is also associated with higher per capita consumption. Individuals living in households with a large number of dependents, as well as Black South Africans, have relatively lower per capita consumption levels, demonstrating how pre-existing markers of vulnerability appear to be associated with lower consumption levels.

Table 3 shows the FE regression estimation findings. Only in specification (4), the coefficient estimate on the drought variable based on the FE regressing approach is positive and marginally significant. When separate regressions are estimated using urban and rural samples, the coefficient estimate on the drought variable is only positive and marginally significant for the urban sample. The coefficient estimate on the interaction term is negative and marginally significant indicating the impact of the drought on consumption decreases with wealth. However, the coefficient estimate on the interaction term is close to zero.

The outcome of the FE model reveals that the 2015/2016 drought did not result in a decline in per capita consumption expenditure. Although the use of fixed effects estimation approach can remove time-invariant individual random effects, but this does not remove unobserved time-varying factors that may correlated with the error term. As a robustness check, we estimate a difference-in-difference (DID) model. However, one of the prerequisites for interpreting coefficient estimations based on the DID model as causal is the parallel trends assumption, which states that the trends of the outcome variable over time for the control and treatment groups are parallel before the start of the treatment. We reject the null hypotheses of parallel trends based on our tests. Several approaches have been developed to relax the parallel trends assumption. For example, Arkhangelsky et al. (2021) proposed a synthetic difference-in-differences (SDID) estimation method that does not rely on the parallel trends assumption or the exogeneity of treatments. The SDID estimator generates optimally weighted matched synthetic control units based on untreated units (unit-specific weights) and pre-treatment times (time-specific weights). We used the SDID estimation approach to estimate our model instead of the standard DID approach.

Table 4 shows the SDID estimation results without including the control variables (column 1) and with including the control variables (columns 2 and 3). The coefficient estimate on the drought variable is not statistically significant in any of the regression models, indicating that the 2015/2016 drought had no significant effect on individual consumption outcomes. We estimated the model separately for rural and urban samples and found no difference in our estimation results. Furthermore, our findings remain the same when we use per capita food consumption expenditure as our welfare indicator, and a different SPEI cut-off point (i.e. SPEI < = − 2) as an in indicator of the 2015/2016 drought.

Overall, our estimation analysis show that the 2015/2016 drought had no significant negative impact on consumption outcomes. One possible explanation for these findings can be related to the structure of the labour market and sources of income of South Africans. For instance, in 2017/2018, about 17 million South Africans were grant recipients (Moosa & Patel, 2020). In addition, subsistence agriculture is not the main source of income for most South Africans, with only about 4% of households participating in subsistence farming (Shifa et al., 2023).

In addition, looking at income distribution deciles indicate that social grants and remittances are the main sources of income for the poor in South Africa (Stats SA, 2019). For example, income from social grants accounts for between 13% and 14% of total household income for households in the bottom two income deciles, and income from remittances accounts for between 12% and 14% for these same households. For households in the bottom two income deciles, the share of labour income to total household income is between 3.7% and 5.6%, respectively. Furthermore, various initiatives from the government and other stakeholders to combat the 2015/2016 drought may have contributed to mitigate the negative effect of the drought on individuals' consumption (see Parliamentary Monitoring Group, 2017). Thus, although the 2015/2016 drought resulted in large reductions in agricultural production and employment in some sectors, this may not translate to a decline in consumption outcomes.

TABLE 4 The effect of the 2015/2016 drought on individuals' welfare (SDID).

	(1)	**(2)**	**(3)**
ATT			
Drought	0.0190	−0.00347	−0.00594
	(0.013)	(0.013)	(0.014)
Controls	No	Yes	Yes
N	12,402	12,402	12,402
NT	37,206	37,206	37,206

Note: Bootstrap standard errors in parentheses.
Source: Authors' estimates using data from WMO and NIDS.

TABLE 5 The effect of the 2015/2016 drought on child WHZ Z-scores (OLS).

	(1)	(2)	(3)	(4)	(5)
Drought	-0.277^{***}	-0.190^{***}	-0.190^{***}	-0.457^{**}	-0.453^{**}
	(0.069)	(0.054)	(0.055)	(0.155)	(0.154)
Wealth (log)			0.0102	−0.00463	−0.0101
			(0.009)	(0.010)	(0.011)
Drought × Wealth				0.0259	0.0261
				(0.015)	(0.015)
Per capita consumption (log)					0.105^{**}
					(0.036)
Controls	No	Yes	Yes	Yes	Yes
_cons	0.699^{***}	0.772^{***}	0.719^{**}	0.883^{***}	0.261
	(0.049)	(0.215)	(0.216)	(0.218)	(0.287)
N	3198	3198	3198	3198	3198
Adj. R^2	0.011	0.102	0.103	0.103	0.106

Notes: Standard errors in parentheses. Standard errors clustered at the pixel ID level.
Source: Authors' estimates using data from WMO and NIDS.

However, we cannot conclude that the drought had no significant negative impact on other well-being outcomes such as nutrition or health. For instance, it is possible that an increase in food prices can reduce the actual amount and quality of food consumed without changes in total consumption expenditure. Existing evidence indicates that changing the pattern and quality of food consumed is among one of the ex-post coping strategies used by households that experienced climate-related shocks (see Gebrehiwot et al., 2021). The impact of such price effects can be analysed using detailed data on nutrition intake indicators other than consumption expenditure. For instance, food insecurity and anthropometric failure indicators such as stunting (height-for-age) and wasting (weight-for height) have been used to analyses the impact of drought on child nutrition and health outcomes (see Dimitrova, 2021; Hirvonen et al., 2020). We use weight-for height (WHZ) and height-for-age (HAZ) Z-scores for children aged between 1 and 5 years old during the 2017 survey years to test whether there is a relationship between drought experience and child nutrition measurers. We evaluate the association between WHZ or HAZ measures and the 2015/2016 drought using the OLS estimation approach (Table 5). We were unable to use FE panel data analysis since we could not use the same children at the specified age group before and after the drought owing to age progression. Table 5 shows the results from OLS estimation using the WHZ variable as a dependent variable and including all the control variables used in our previous analyses above.

The results demonstrate a negative and statistically significant relationship between the WHZ scores and drought experience. This means that children in drought-affected areas have lower WHZ than children in non-drought-affected areas. Even after controlling for per capita consumption in our model (column 5), the result stays the same. In contrast, we find no statistically significant relationship between child HAZ measurements and drought indicators (Table A3 in Appendix S1). This is feasible because, whereas stunting (lower HAZ) is caused by long-term disease exposure and insufficient food intake, wasting (lower WHZ) is caused by sudden weight loss over a short period of time (see Dimitrova, 2021). As a result, the WHZ indicator is better suited for capturing the immediate impact of the 2015/2016 drought on child nutrition. The negative relationship between the WHZ measures and the 2015/2016 drought suggests that households may have used welfare-costly coping strategies such as reducing the quantity and quality of food consumed by children, which may have exacerbated childhood malnutrition. However, because we used the OLS estimation method, the negative relationship between WHZ and the drought variables cannot be considered as causal.

5 | CONCLUSIONS

In this paper, we examine whether the 2015/2016 drought negatively affected individuals' welfare in South Africa and whether access to assets explained individuals' ability to mitigate the negative effects of the drought on individual welfare. We combined a nationally representative survey dataset from NIDS with weather data from meteorological satellites for this purpose. We use real per capita consumption expenditure and anthropometric measures to measure individual welfare.

We find that existing markers of marginalisation (having a large number of dependents, relying on social grants or belonging to specific racial categories) are associated with lower per capita consumption levels, whereas higher wealth values are associated with higher consumption. However, we find no evidence of a significant negative impact of the 2015/2016 drought on individual per capita consumption expenditure.

Our findings suggest that, while climate-related shocks such as droughts can reduce agricultural production and employment in some sectors, the extent to which climate-related shocks affect individual welfare outcomes is determined by factors such as coping capacity, access to insurance and social safety nets and government responses. The lack of a statistically significant negative effect of the 2015/2016 drought on individual consumption expenditure in South Africa may be explained in part by the labour market structure, in which farming income is more associated with industrial farming than subsistence farming, combined with the fact that a large share of the low-income population relies on non-labour income sources such as social grants and remittances.

Using anthropometric measures, however, we find a negative and statistically significant relationship between children's WHZ readings and drought experience. This means that children lived in drought-affected areas had lower WHZ than children lived in non-drought-affected areas. This result suggests that households may have used welfare-costly coping strategies such as reducing the quantity and quality of food consumed by children, which could contribute to child malnutrition. Furthermore, our findings suggest that using per capita consumption expenditure as a measure of welfare may have limitations in capturing the negative effects of climate-related shocks on other well-being outcomes, such as nutrition or other health outcomes. More research is needed to quantify the impact of climate-related shocks like droughts on other indicators of well-being in South Africa.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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