International Inequalities Institute

WORKING PAPER 153

The Rising Tide: Floods as Drivers of Income and Welfare Inequality in South Africa

Enrico Nichelatti
Institute for Research on Socio-Economic Inequalities, University of Luxembourg

Annalena Oppel
International Inequalities Institute, LSE

Abrams Tagem
African Tax Administration Forum (ATAF)

NOVEMBER 2025

Enrico Nichelatti
Institute for Research on Socio-Economic Inequalities, University of Luxembourg

Annalena Oppel
International Inequalities Institute, LSE

Abrams Tagem
African Tax Administration Forum (ATAF)

In addition to our working papers series all these publications are available to download free from our website: www.lse.ac.uk/III

International Inequalities Institute
The London School of Economics and Political Science, Houghton Street, London WC2A 2AE

E Inequalities.institute@lse.ac.uk
W www.lse.ac.uk/III
𝕏 @LSEInequalities

International Inequalities Institute

The Rising Tide: Floods as Drivers of Income and Welfare Inequality in South Africa

Nichelatti Enrico[1], Oppel Annalena[2], Tagem Abrams[3]

Abstract

This paper examines how floods impact inequality in South Africa by linking georeferenced flood data with cross-sectional household and individual data from the National Income Dynamics Study survey. Using a difference-in-differences estimation, we assess the causal effects of five major flood events between 2008 and 2017 on individual welfare across multiple dimensions: labour income, income with social benefits, post-fiscal income, consumption, and material deprivation. Our findings reveal that floods significantly reduce all income measures for individuals within 0.5 km of flood zones, with substantial spill-over effects extending to 1 km. While South Africa's extensive social grant system provides some cushioning, it is insufficiently shock-responsive to prevent welfare declines. Post-fiscal income falls as coverage gaps exclude informal workers, grant values erode due to post-disaster inflation, and indirect taxes continue to burden affected individuals. Floods also reduce individual consumption and increase material deprivation by destroying assets, disrupting markets, and raising the cost of essentials. These effects are particularly severe for low-income individuals in informal settlements, who face disproportionate exposure, limited recovery capacity, and prolonged deprivation. Our results demonstrate that floods are not merely environmental shocks but powerful drivers of inequality that interact with South Africa's pre-existing spatial, racial, and economic disparities. The findings underscore the need for shock-responsive social protection, resilient infrastructure investment, and equitable climate adaptation policies to prevent floods from further entrenching structural inequality.

Keywords: inequality, climate change, floods, South Africa, individual welfare

JEL Classification: C21, H53, I32, O55, Q51

[1] Institute for Research on Socio-Economic Inequalities, University of Luxembourg.
[2] International Inequalities Institute, London School of Economics and Political Science.
[3] African Tax Administration Forum (ATAF).

1 Introduction

Climate change is intensifying extreme weather events globally, with floods emerging as one of the most destructive and recurrent disasters affecting vulnerable populations more (Dorland et al. 2003). In South Africa, floods have become increasingly frequent and severe, driven by shifting rainfall patterns, inadequate infrastructure, and rapid urbanization that pushes low-income households into high-risk areas (Díaz Pabón et al. 2024). These disasters do not affect all communities equally. Instead, they intersect with the country's deep-rooted structural inequalities that are shaped by a legacy of racialised spatial planning, persistent unemployment, and widespread poverty. Those structural inequalities lead to profoundly unequal outcomes. Understanding how climate disasters, specifically floods, impact inequality is therefore not merely an environmental question but a fundamental issue of inclusive and equitable development. The paper asks: how do floods affect individual income and welfare inequality in South Africa?

South Africa provides a particularly compelling context for examining the relationship between climate disasters and inequality. As one of the most unequal societies in the world, with a Gini coefficient consistently above 0.60, the country faces a precarious convergence of climate vulnerability and socio-economic fragility (Shifa et al. 2023). Historical apartheid-era policies confined Black and Coloured populations to marginalised urban peripheries and rural areas, many of which are now recognised as flood-prone zones (Khandlhela and May 2006). Today, informal settlements with inadequate drainage, weak housing structures, and limited access to essential services remain highly exposed to flooding (David et al. 2025). When disasters strike, poor households not only suffer greater immediate losses but also lack the financial resources, insurance coverage, and institutional support needed for recovery. This creates a vicious cycle in which floods deepen poverty, erode resilience, and widen the gap between rich and poor (Vin and Kawasaki 2024), which is also common in urban areas (Winsemius et al. 2018).

Despite growing recognition of climate-related risks, empirical evidence on how floods affect inequality over time in South Africa remains limited. Existing research has largely focused on small-scale case studies of specific events or communities (Bouchard et al. 2023), with few attempts to assess causal impacts across time and space using nationally representative data. Shifa et al. (2023) use NIDS survey data to analyse inequalities in multidimensional climate-related vulnerability and show that such vulnerability has been reducing over the years, although material deprivation still prevails. This gap is critical because without robust evidence, policy responses risk being reactive, fragmented, and inequitable. An incomplete picture could potentially reinforce rather than alleviate the disparities that make certain populations vulnerable in the first place. Moreover, floods affect households not only through direct income losses but also by undermining consumption, increasing material deprivation, and straining already limited social protection systems (Shifa et al. 2023). This is exacerbated by the fact that most of losses incurred due to flooding are uninsured. Khandlhela and May (2006) analyse the impact, coping and adapting strategies of households after the 2000 flood in Limpopo and show that due to the inherent deprivation in the communities analysed, the flood exacerbated poverty and deprivation. World Bank (2022) uses standardized precipitation data and household surveys to estimate the incidence and distribution of floods on per capita household consumption in Southern African Customs Union (SACU) member countries. The findings show a steep reduction in consumption in response to floods, and while social protection programs potentially offset some of the consumption losses, the system covers only a fraction of vulnerable households and individuals. A comprehensive analysis that captures these multidimensional welfare effects is essential for designing adaptation strategies that are both effective and just.

This paper addresses these gaps by examining the causal impact of floods on inequality in South Africa using a difference-in-differences (DiD) approach applied to georeferenced flood data and cross-sectional household and individual data from the National Income Dynamics Study (NIDS) dataset. We analyse five major flood events that occurred between 2008 and 2017, assessing their effects on labour income, income with social benefits, post-fiscal income, individual consumption, and material deprivation. By distinguishing between individuals in high-intensity exposure zones (within 0.5 km of flood centroids) and lower-intensity zones (0.6–1 km away), we are able to test for close-response effects and trace how flood impacts radiate beyond directly affected areas. Our findings reveal that floods significantly reduce all measures of individual welfare, with the largest losses concentrated among the poorest and most vulnerable groups (Justino et al. 2025 and Santoro and Santos 2020 provide similar findings for Mozambique). Critically, we show that while South Africa's extensive social grant system provides some cushioning, it is insufficiently shock-responsive to prevent substantial declines in post-fiscal income and living standards.

The paper makes three key contributions to the literature. First, it provides one of the few micro-level analyses of the causal impact of floods on multiple dimensions of inequality in South Africa, linking geospatial flood data to nationally representative household panel data. This allows estimation of effects on both market and non-market welfare channels, underscoring the robustness of core findings. Second, the study advances the understanding of the spatial transmission of flood impacts by distinguishing between effects within 0.5km (i.e., what we call direct exposure) and 1km (indirect exposure), revealing how income and welfare losses propagate through direct and also spill-over networks. Third, the study contributes to policy-relevant evidence on the limits of social protection and fiscal redistribution in mitigating disaster-induced inequality. By demonstrating that income after social benefits and post-fiscal income also decline after floods, the paper highlights the need for shock-responsive social protection and adaptive, holistic fiscal design.

The paper proceeds as follows. Section 2 reviews the international and South African literature on floods, inequality, and vulnerability, situating our study within broader debates on disaster-driven inequality. Section 3 provides an overview of flood risks in South Africa and describes the five flood events analysed in this study. Section 4 outlines our empirical strategy, data sources, and variable construction. Section 5 presents the main results, demonstrating the adverse effects of floods across income, consumption, and deprivation measures. Section 6 discusses the implications of our findings for policy and theory, emphasising the need for shock-responsive social protection, resilient infrastructure investment, and spatially targeted climate adaptation. By linking climate shocks to inequality dynamics, this paper contributes to both the disaster risk literature and the broader effort to build more equitable and resilient societies in an era of accelerating climate change.

2 Literature review

Climate change is projected to intensify rainfall variability and increase the frequency and severity of extreme weather events, including floods. While such events affect broad populations, their consequences are distributed unevenly, often amplifying pre-existing inequalities. In South Africa, legacies of racialised spatial planning, persistent poverty and uneven development (Branson et al. 2024; Leibbrandt et al. 2007; 2012), have the potential to intersect with climate risks, rendering some communities far more vulnerable to flood impacts than others. Understanding how flood exposure relates to inequality in this context is critical for developing equitable climate adaptation and disaster risk reduction strategies.

Extreme weather events such as heavy rainfall and droughts are key triggers of disasters that can devastate livelihoods (Dorland et al. 2003). Disasters do not affect all groups equally; those with fewer resources often face heightened risks and have fewer means to recover (Tovar Reaños 2021), thus widening the gap between the poor and the rich (Vin and Kawasaki 2024). The Intergovernmental Panel on Climate Change (IPCC, 2001) notes that living in hazard-prone areas is often not a choice but a necessity for those lacking alternative housing options. This reinforces the 'poverty-disaster' cycle described by Hallegatte et al. (2020) in which poverty increases vulnerability to disasters, and disasters in turn exacerbate poverty. Globally, evidence suggests that the immediate aftermath of disasters tends to increase inequality, especially in countries with inherently higher levels of inequality (Cappelli et al. 2021), even if the effects may diminish over the longer term (Yamamura 2015). However, vulnerability is highly context-specific, shaped by local demographic, socio-economic, and infrastructural factors (Cutter et al. 2003; Morrow 2002).

Winsemius et al. (2016) separate the impacts of climate change from socio-economic development such as population growth or urbanisation, showing that in African countries, socio-economic changes currently drive most increases in flood risk, but when normalised to GDP, climate change emerges as the dominant driver. South Africa mirrors this continent-wide trend. The country is undergoing rapid urban transformation with 71 per cent of its population expected to live in cities by 2023 (Harrison 2016). At the same time, the urban poor are increasingly vulnerable to climate variability with a majority lacking the means to cope with consequences; often only including reactive-type measures without resilience building elements (Hlahla and Hill 2018). This also speaks to findings in Hallegatte et al. (2020) who stress that poor people are more likely to experience environmental shocks, lose more relative to their wealth, and receive less post-shock support. Globally, Winsemius et al. (2016) further demonstrate that poor populations in Africa are disproportionately exposed to both floods and droughts.

The unequal impacts of floods can be understood through three interconnected dimensions: exposure, vulnerability, and socio-economic resilience (David et al. 2025). Flood exposure refers to the extent to which people and assets are physically located in flood-prone areas. There is increasing evidence of a growing concentration of people and assets in flood-prone areas, which is compounded by policy failures, poor planning decisions and chronic underinvestment in flood protection. Social distribution studies, such as Fielding and Burningham (2005) in the UK, reveal that lower socio-economic groups are often overrepresented in high-risk zones. This pattern is also seen elsewhere: in the US, areas affected by major flood disasters tend to attract less affluent and less creditworthy homebuyers, reinforcing cycles of exposure and marginalisation (Ratnadiwakara and Venugopal 2020). In Vietnam, while national analyses found no systematic link between poverty and flood exposure, city-level evidence from Ho Chi Minh City shows slum areas to be disproportionately exposed (Bangalore et al. 2019). In Bangladesh, chronic conditions associated with poverty, were often further complicated by disaster exposure, worsening disease patterns and in turn economic conditions (Akther and Ahmad 2022).

Vulnerability captures the susceptibility to harm given exposure. Lindersson et al. (2023) show that income inequality is significantly associated with higher flood mortality in middle- and high-income countries, suggesting that wealth disparities weaken societal capacity to protect lives. In the aftermath of Hurricane Katrina, low-income Black homeowners were the most severely impacted, highlighting the intersection of race and class (Elliott and Pais 2006). In low- and middle-income contexts, vulnerability is often tied to livelihood dependence on climate-sensitive resources. A study in rural Sri Lanka shows that low-income households suffer greater proportional losses than wealthier households (De Silva and Kawasaki 2018). Similarly, Hossain et al. (2020) document in Bangladesh that floods reduce earnings, erode preparedness, and increase debt burdens, locking vulnerable households into cycles of loss. Zhou et al. (2022) review South African specific literature and show that rural households are more vulnerable to climate-related shocks than urban households due to differences in infrastructure, livelihoods and broad income-generating activities.

Resilience refers to the ability to absorb, recover from, and adapt to shocks. Recurrent flooding can erode resilience over time, as found in Myanmar, where low-income households not only suffered higher damages but also had to borrow more frequently, leading to sustained economic decline (Kawasaki and Shimomura 2024). In Thailand, even when poor and wealthy households experienced similar flood conditions, the wealthy maintained stability, while the poor faced prolonged educational and livelihood disruptions (Vin et al. 2025). These dynamics echo the South African context, where recurrent flooding in informal settlements often results in asset loss, income reduction, food insecurity and school attendance disruptions, deepening and exacerbating long-term vulnerability and horizontal inequality (Dlamini et al. 2024; Jewkes et al. 2023).

Several global patterns are particularly relevant to South Africa's context. As seen in the UK, US, and Asian cities, poorer households are often concentrated in hazard-prone zones (Fielding and Burningham 2005; Ratnadiwakara and Venugopal 2020; Bangalore et al. 2019). In South Africa, historical segregation and housing backlogs similarly push low-income and informal settlements into floodplains, riverbanks, and inadequately drained areas (Marutlulle 2021; Shifa et al. 2023; Díaz Pabón et al. 2024). Evidence from Bangladesh (Hossain et al. 2020), Sri Lanka (De Silva and Kawasaki 2018) and Myanmar (Kawasaki and Shimomura 2024) shows that poverty intensifies the damage sustained and limits recovery capacity, a dynamic that resonates locally where high unemployment and precarious work amplify disaster impacts. Recurrent flooding not only reduces current income but also undermines future opportunities through disrupted education (Vin et al., 2025). In South Africa, where education is a key pathway out of poverty, such disruptions risk perpetuating long-term structural inequality. Lindersson et al. (2023) further show that unequal societies experience higher flood mortality, a finding that aligns with concerns that South Africa's high Gini coefficient may exacerbate disaster-related fatalities, especially where emergency services are unevenly distributed. The poverty–disaster feedback loop described by Hallegatte et al. (2020) and observed globally illustrates how floods can entrench inequality, particularly when recovery support is inadequate or inaccessible to the poor.

While international research has established robust evidence on the connections between inequality and flood impacts, South African-specific literature remains limited. Existing studies focus more on small-scale assessments linked to specific events with limited longitudinal research tracking how repeated flood events affect income distribution, educational attainment, and intergenerational mobility. Given the country's unique socio-historical context, research should pay close attention to how race, class, and geography intersect to shape flood impact, exposure and adaptive capacity. Integrating flood modelling with household-level socio-economic surveys would enable a more nuanced understanding of who is most at risk, why, and how interventions can be designed to reduce both exposure and vulnerability. Such an approach is essential for ensuring that climate adaptation policies do not inadvertently exacerbate inequality. As Linnerooth-Bayer and Hochrainer-Stigler (2015) caution further, traditional risk financing mechanisms may be insufficient for catastrophic events and could leave the poorest households without meaningful safety nets.

In sum, review of the relationship between inequality and flood exposure is neither incidental, uniform nor random. Instead, it is produced and reproduced through spatial patterns, livelihood vulnerabilities, and unequal access to recovery resources. Initial levels of poverty and inequality force disadvantaged households to live in more flood-prone areas, further increasing their exposure to floods, while simultaneously damaging their ability to cope with and recover from the floods. While global studies offer clear evidence of these mechanisms, South Africa's context demands a spatially grounded analysis (see section three for the specific events we focus on) that can inform equitable adaptation strategies in an era of intensifying climate change. In addition, there's a dearth of causal analysis that combines the interconnected dimensions of exposure, vulnerability and resilience in analysing the impact of floods on individual welfare in South Africa.

In our approach, we thus specifically focus on inequality as a process across short-term and long-term outcomes to better understand how the consequences of flood affect inequality overall. More specifically, inequality is then understood as a divergence in welfare outcomes across affected and unaffected populations. Generally, the relationship between floods and inequality in South Africa can be understood through a multidimensional lens that combines income-based and non-monetary measures of welfare with the core concepts of exposure, vulnerability, and resilience (Islam and Winkel 2017; Shifa et al. 2023; Winsemius et al. 2016). Income inequality is assessed through labour income, income with social benefits, and post-fiscal income, while household consumption (both food and non-food) and material deprivation capture broader living standards. This framework highlights how floods act as both shocks to immediate livelihoods and catalysts for long-term disparities and entrenched inequalities. Labour income losses from destroyed workplaces, disrupted transport, and damaged assets reduce the primary source of household resources, particularly in the informal sector (Khandlhela and May 2006). Although social grants cushion some of these shocks, recovery support may be unavailable to the poor (Hallegate et al. 2020) or poorly coordinated and/or mismanaged (Khandlhela and May 2006), while post-fiscal income often declines as limited coverage, inflation, and persistent taxation (especially indirect taxes like VAT and excises) undermine redistributive effectiveness. Individual consumption and material deprivation provide complementary perspectives: households not only lose earnings but also struggle to meet basic needs when food prices rise, services collapse, or homes and durable goods are destroyed (David et al. 2025). By combining these dimensions, inequality is captured as a process that links short-term income losses with longer-term living standard declines, amplifying South Africa's already high Gini coefficient (Shifa et al. 2023).

3 Mapping flood risks in South Africa

South Africa's flood risk is rising due to the convergence of climate change, infrastructure weaknesses, rapid urbanization, and unequal social conditions (Govender et al. 2025). For example, recent reviews emphasized the fact that the country is facing more frequent and intense rainfall events, itself caused by changes in regional precipitation patterns (Davenport et al. 2021). Changes in climate patterns, specifically the Indian Ocean Dipole and the Madden-Julian Oscillation, contribute to unpredictable and severe weather in the region, whereby rising global temperatures amplify these cycles further (Matladi 2025). Hereby, vulnerable communities are more severely impacted include low-income earners, informal settlements, women and marginalised populations.

Across recent years, severe flooding has led to substantial direct financial losses, also impacting businesses across various industries by reducing water supply, damaging infrastructure and increasing operational costs (PricewaterhouseCoopers 2025). In addition, struggling with infrastructure vulnerability means many cities and informal settlements have inadequate drainage systems and insufficient infrastructure to cope with extreme rainfall, making them especially vulnerable to flooding and flood-related damages (Kergozou 2025). The extent and impact of floods in South Africa is further worsened by the rising urbanisation rate and land-use changes that in turn lead to deforestation through the expansion of urban areas where illegal dumping reduces the land's ability to absorb excess water (Haskoning 2021; Matladi 2025). Scholars have further stressed that socioeconomic pressures such as housing shortages and economic deprivation drive people to build homes in flood-prone, high-risk locations (Dlamini et al. 2024). Institutional barriers further complicate the issue. For instance, water management challenges often tend to exacerbate existing inequalities due to poor or inequitable water rights, underfunded municipal services and again, poorly maintained infrastructure (Kergozou 2025).

Studies also provided further insights on different forms of hardship experienced as a consequence of floods. For very low-income households impacted by the floods in April 2022 across KwaZulu-Natal, this included emotional impacts and daily struggles, where many described the floods as 'heart-breaking' in light of collapsing homes, lost lives, and children being swept away (Bouchard et al. 2023; Jewkes et al. 2023). Yet, life seemed to continue 'much as before' once the immediate crisis passed, often by relying on strong community bonds. Khandlhela and May (2006) document the stress from the loss of assets of social and cultural importance, including documents needed to prove eligibility for social grants, following the 2000 flood in Malamulele district in Limpompo province. Another study looking at urban poor communities in Pietermaritzburg, KwaZulu-Natal, however highlight that coping strategies are predominantly reactive and short-term (Hlahla and Hill 2018). Strategies that work in the short but not for long-term resilience include digging draining canals during floods or using buckets to store water during drought. However, these methods are unsustainable and reflect broader underinvestment in flood protection. The authors further stress that in comparison with rural contexts, there tends to be less reliance on social networks in urban communities. Specifically, when the crisis affects many, neighbourly support becomes unreliable. This is further paired with a doubt in institutional support, concerning the effectiveness and trustworthiness of the government or NGOs, but also with regards to weather forecasts or early warning systems. Here, some residents also attribute climate variability to divine power or natural order, limiting awareness of climate change which creates barriers to proactive adaptation and trust in formal institutions.

In light of such challenges, South Africa has extended some of its policy measures and adaptation strategies. This includes the 2020 National Climate Change Adaptation Strategy (NCCAS) which is now incorporated in the 2024 Climate Change Act. It aims to improve water supply security, flood protection, and climate-resilient agriculture and infrastructure. Yet, recent reviews found that implementation of such measures face funding, governance, and infrastructural challenges (Kergozou 2025). The country also enhanced its approach to disaster risk insurance. There is ongoing consideration and rollout of parametric insurance products[4] which pay out rapidly when specific events – like flood thresholds – occur. Yet, current coverage remains limited, focussed on higher-income sectors and commercial agriculture, with public infrastructure, the informal sector or small-scale businesses largely uninsured (Government 2025). Some municipalities have insurance pools, yet coverage remains limited due to asset management issues with a need to expand protection to public assets and vulnerable communities (ibid.)

Recent flood events affected provinces such as the one in KwaZulu-Natal in 2022. Also Gauteng, and the North-West suffered major floods, resulting in loss of life, displacement, infrastructure destruction, and serious disruption of daily life (Bouchard et al. 2023; GDACS 2025). In this study, we specifically focus on the following flood events: 19 June 2008, 12 November 2008, 1 February 2011, 17 January 2012, and 9 March 2017. The selection spans recent events over the past two decades and also enables us to map flood events onto the national census data for measuring their impact on inequality relevant measures of our study, especially measuring inequality across short-term income losses due to flood events with living standard declines in the long term.

[4] Parametric insurance describes a type of insurance contract that insures a policyholder against the occurrence of a specific event by paying a set amount based on the magnitude of the event, as opposed to the magnitude of the losses in a traditional indemnity policy

Table 1: Flood events in South Africa since 2008

Flood event	Duration	Displaced people	Area affected in sq km	Trend for region	Cause
19th June 2008	3 days	4000	403	13% increase	Heavy rain
12th November 2008	5 days	100	52.5	56.5% increase	Heavy rain
1st February 2011	15 days	5000	202	6.2% increase	Heavy rain
17th January 2012	28 days	100,000	2.79k	122.8% increase	Tropical storm, surge
9th March 2017	13 days	0	802	398.4% increase	Heavy rain

Note: Global Floods Database 2025, trend refers to population exposed to flooding within region between 2000 and 2015, 17th January flood also reported 37 casualties.

Source: authors' construction.

Concerning the flood events displayed in Table 1, the earlier 2008 events appear more localized: the June flood in the KwaZulu-Natal region only lasting 3 days nevertheless displaced 4,000 people across 403 sq km, while the November event in the Montagu region lasting 5 days then affecting only 100 people across 52.5 sq km. The February 2011 flood affected the Limpopo Province, particularly the Thulamela Local Municipality in the Vhembe District, where 246 houses were damaged (Musyoki et al. 2016). This relatively contained event lasted 15 days and displaced 5,000 people across 202 sq km. In stark contrast, the January 2012 event was triggered by Subtropical Depression Dando, which struck southern Mozambique before affecting South Africa's Mpumalanga and Limpopo provinces, causing 37 casualties overall. This 28-day event proved more severe, displacing 100,000 people across 2,790 sq km. This also meant a significantly higher proportion of the region's population being exposed to flooding in the 2000-2015 period. The March 2017 flood in the Northwest regions, though producing no reported displacement, affected 802 sq km over 13 days with the highest regional trend increase of 398.4 per cent, suggesting a significant shift in flood patterns. The progression reveals an escalating trajectory: from relatively contained short-duration events in 2008 to the catastrophic tropical storm-driven disaster of 2012, we observe events of different severity in the country. To date, longitudinal comparison of flood events in South Africa are still lacking. In connecting different flood events across time, we can not only compare the impact of floods but also link their impact to their specificities.

4 Empirical approach

4.1 Data

This study combines georeferenced flood data with nationally representative cross-sectional household and indiviual data from the National Income Dynamics Study (NIDS) dataset (SALDRU, 2008, 2011, 2012, 2017) to estimate the causal impact of floods on individual welfare outcomes. Flood data were sourced from the Dartmouth Flood Observatory (DFO) (Dartmouth Flood Observatory, 2021), which provides centroids for all recorded flood events in South Africa. Using these centroids, we calculated distances between NIDS individual locations and the nearest flood events.

The analysis seeks to establish the causal impact of floods on various measures of individual income in South Africa and to assess whether the magnitude of this effect varies with the degree of exposure. A related objective is to examine whether the consequences of floods extend beyond income to affect individual consumption and multidimensional deprivation, and whether the findings are consistent across these different measures of individual well-being.

Exposure to floods is defined in two steps. First, we created two treatment groups based on spatial proximity: individuals located within 0.5 km of a flood centroid, representing high-intensity exposure, and individuals located between 0.6 and 1 km, representing lower-intensity exposure. This distinction allows us to test whether individuals in closer proximity to the floods experience larger income and welfare losses than those further away. The choice of up to 1km permits testing for the direct effects, first-order impacts (i.e., through physical damage) and the indirect, second-order spill-over effects (i.e., through economic linkages, such as service interruptions, market contraction and infrastructure disruption). In addition, the choice focuses on the economically meaningful area of flood impact while avoiding dilution from unaffected households further away (robustness tests discussed below test for wider flood perimeters). Second, we incorporated timing by matching flood event dates to NIDS interview dates. An individual was considered affected only if the interview took place during or after the occurrence of a nearby flood. Specifically, we used the following flood events recorded in the Global Flood Database: 19 June 2008, 12 November 2008, 1 February 2011, 17 January 2012, and 9 March 2017 (see section 3).

The NIDS survey consists of multiple nationally representative survey waves that can be treated as repeated cross-sections of individuals over time. It provides rich socioeconomic data across five survey waves, including demographic and housing characteristics, food and non-food consumption expenditure, and sources of individual income and wealth. For this study, we used Waves 1, 2, 3, and 5. Wave 4 was excluded from the analysis because no flood events were recorded during that period. Household-level income was converted into individual-level measures by dividing totals by household size. Three income indicators were constructed: (i) labour income, representing earnings from employment and self-employment; (ii) income with social benefits, which includes labour income and all social grants and transfers; and (iii) post-fiscal income, defined as disposable income after accounting for taxes and transfers. Control variables include demographic and socioeconomic characteristics harmonized across all waves, namely population group, years of education, gender, age, and work status (Diaz Pabon et al. 2024; Salvucci and Santos, 2020). Summary statistics for all income, consumption, deprivation, and control variables across the four waves provide descriptive context for the analysis and demonstrate stability in individuals characteristics and exposure distributions (see Table A3, A4, A5 and A6 in the appendix). Table 2 reports the number of observations for the treated and control groups for each wave and both radii.

These three income measures are of central interest because they allow us to examine the role of government in mitigating the consequences of floods and ultimately in shaping inequality. While labour income reflects individuals' own market earnings, income with social benefits incorporates redistributive policies through grants and transfers. Post-fiscal income further accounts for taxation (both direct and indirect), thereby capturing the final distributional outcome after both government transfers and fiscal obligations. Earlier studies focussing on climate change events have suggested that social grants alongside remittances are a primary source of income for people at the bottom of the consumption distribution (Díaz Pabón et al. 2024). By analysing these measures sequentially, we can assess to what extent social protection systems and tax policies cushion individuals from flood-induced income losses and whether these mechanisms reduce or exacerbate inequality. Table A1 in the appendix reports the income sources for each income type.

In addition to income, we considered two alternative welfare indicators. First, we constructed a measure of per capita consumption by summing all reported household expenditures and dividing by household size (Table A1 reports the various sources of consumption, both food and non-food consumption). Second, we developed a material deprivation index capturing non-monetary aspects of living conditions. The index is the unweighted sum of ten binary indicators reflecting basic service access and housing quality, including wall materials, water source, type of toilet, cooking fuel, heating and lighting sources, telephone access (landline and mobile), waste disposal, and street lighting. Each variable was recoded into 0/1 format, where 1 indicates deprivation and 0 indicates non-deprivation (see Table A2 for details). The index ranges from 0 to 10, with higher scores reflecting greater deprivation (Khandlhela and May 2006 use some of the above indices to demonstrate inherent deprivation and the impact of the 2000 flood in Limpopo).

To ensure that results were not driven by extreme values, all income and consumption variables were subjected to a process of outlier elimination through top-coding. Specifically, values exceeding wave-specific thresholds were replaced with the threshold itself. For example, post-fiscal income values above 50,000 in Wave 1, 100,000 in Wave 2, and progressively higher thresholds in later waves were top-coded, while consumption values were adjusted by setting negative reports to missing. This procedure reduces the influence of outliers while retaining information on the upper tail of the distribution, thereby yielding more robust estimates.

Table 2: Summary statistics of DiD

	Wave 1	Wave 2	Wave 3	Wave 5
Treated 0.5km radius	7,720	8,965	8,553	7,601
Control 0.5km radius	51,948	50,712	51,115	52,067
Treated 1km radius	6,326	7,448	7,087	6,357
Control 1km radius	53,342	52,220	52,581	53,311

Source: authors' creation by using NIDS secure data and the Global Flood Database.

To estimate causal effects, we employed a DiD strategy, comparing changes in welfare outcomes over time between treated and comparison individuals. The DiD is appropriate in this context because floods are localised and time-bound shocks that affect only a subset of individuals (those living near flood centroids during or after each event), while the remaining individuals in the same waves serve as a natural comparison group (Angrist and Pischke 2009). This quasi-experimental design exploits the cross-sectional structure of the NIDS data, tracking individuals before and after flood events, to remove time-invariant unobserved heterogeneity. By comparing changes over time in treated versus non-treated individuals, the DiD estimator isolates the average treatment effect of flood exposure, net of general macroeconomic shocks or nationwide policy shifts that would have influenced all individuals equally.

The method further benefits from the availability of multiple flood events over different survey waves (2008, 2011, 2012, 2017) and spatial variation in exposure (0.5 km vs 0.6–1 km radii). This enhances statistical power and enables testing for treatment effects, as closer proximity plausibly represents higher-intensity treatment. The inclusion of demographic and socioeconomic controls (population group, education, age, gender, work status) improves precision and limits residual confounding from compositional changes between groups.

The model is specified as follows:

$$Y_{it} = \alpha + \beta_1 Treated_i + \beta_2 Post_t + \delta(Treated_i x Post_t) + \gamma X_{it} + e_{it} \quad (1)$$

Where Y_{it} denotes one of the outcome variables (labour income, income with social benefits, post-fiscal income, consumption, or the deprivation index) for individual i at time t; $Treated_i$ indicates individuals located within the defined exposure radii; $Post_t$ denotes periods after a flood event; and X_{it} includes demographic and socioeconomic control variables The interaction coefficient δ captures the average treatment effect of flood exposure (the effect of the treatment, i.e., the DiD estimator). Standard errors were clustered at the individual level to account for within-individual correlation. We treat income measures as the primary outcomes for assessing inequality and flood impacts, while consumption and the deprivation index serve as robustness checks to validate findings across monetary and non-monetary welfare dimensions.

The analysis conducts sensitivity and robustness checks to assess the consistency of the estimated effects of floods on income by employing alternative welfare measures, consumption and a material deprivation index, as well as using a different variable from the Integrated Public Use Microdata Series (IPUMS) database, available only for 2011, since the data collection occurred before or during the flood that began on 1 February 2011. We apply an alternative statistical approach (multilevel regression), with the corresponding results presented in Appendix Table A11 and discussed in the results section.

5 Results and Discussion

The results from estimating equation (1) using the DiD estimator are presented in Tables 3-8: labour income (Tables 3 and 4), income with social benefits (Tables 5 and 6) and post-fiscal income (Tables 7 and 8). Each table reports findings drawn on four waves of NIDS data, specifically waves 1, 2, 3 and 5 (see Section 4.1 above).

5.1 Baseline Results

Floods have a strong adverse impact on labour income since they simultaneously disrupt both the demand for and supply of labour. On the demand side, floods damage workplaces, infrastructure, and productive assets, particularly in flood-prone townships and informal settlements where businesses and individuals often lack insurance or necessary savings (Silva and Kawasaki 2018). Firms may also incur losses from business interruptions, e.g., temporarily close or scale back operations, especially firms with low working capital and limited insurance coverage, which results in job losses for individuals (Endendijk et al. 2024).In addition, informal traders and small-scale farmers lose stock, tools, and crops, which are often uninsured (Khandlhela and May 2006). Floods also reduce the ability of employers and self-employed workers to generate income, leading to immediate declines in wages, working hours, and job opportunities. On the supply side, floods hinder workers' capacity to participate in the labour market. Damaged transport routes prevent commuting, while health risks from waterborne diseases, injury, and stress reduce productivity (Bouchard et al. 2023; Khandlhela and May 2006). Individuals must also divert time to recovery tasks such as repairs and caregiving, further lowering available labour supply.

The impacts are most severe for individuals within 0.5 km of flood zones, where direct destruction of assets and workplaces is concentrated. However, the effects spill over into surrounding areas up to 1 km away, albeit with smaller coefficients. These indirect impacts arise because local demand inevitably slows down when affected households cut spending, supply chains are disrupted, and infrastructure damage radiates beyond the immediate flood zone (David et al. 2025; Yan 2025). In

South Africa's context, where informal work is a major source of livelihoods and workers, especially low earners, are highly vulnerable to shocks, these mechanisms combine to create sharp losses in labour income after floods, exacerbating inequality and slowing recovery.

Table 3: Effect of floods on labour income, 0.5 km radius

	Wave 1	Wave 2	Wave 3	Wave 5
Floods	-161***	-107**	-231***	-421***
Pop. group				
Black	0.00	0.00	0.00	0.00
Coloured	133**	195***	139***	122
Asian/Indian	2,149***	2,009***	3,057***	2,467***
White	5,228 ***	5,660***	6,343***	11,004***
Other	-	4,059*	-	7,314***
Education	113***	94***	125***	222***
Gender				
Male	0.00	0.00	0.00	0.00
Female	-187***	-192***	-284***	-548***
Age	14***	11***	15***	27***
Work status				
Unemployed	0.00	0.00	0.00	0.00
Employed	1,190***	1,209***	1,358***	2,165***
Casual worker	317***	149	15	177
Self-employed	728***	821***	1,017***	2,377***
Variance Inflation Factors (VIF)	1.17	1.12	1.14	1.13
Robust standard error	Yes	Yes	Yes	Yes
R^2	31%	26%	27%	27%
N	15,435	17,411	18,633	23,802

Note: $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: authors' creation by using NIDS secure data and the Global Flood Database.

Table 4: Effect of floods on labour income, 0.6-1 km radius

	Wave 1	Wave 2	Wave 3	Wave 5
Floods	-108***	-67***	-132***	-146***
Pop. group				
Black	0.00	0.00	0.00	0.00
Coloured	158***	213***	174***	184*
Asian/Indian	2,180***	2,021***	3,104***	2,447***
White	5,231***	5,666***	6,352***	11,026***
Other	-	4,055*	-	7,397***
Education	113***	94***	126***	224***
Gender				
Male	0.00	0.00	0.00	0.00
Female	-188***	-193***	-286***	-552***
Age	13***	12***	15***	27***
Work status				
Unemployed	0.00	0.00	0.00	0.00
Employed	1,192***	1,211***	1,362***	2,172***
Casual worker	322***	1,50	149	191
Self-employed	726***	826***	1,015***	2,383***

Variance Inflation Factors (VIF)	1.17	1.12	1.14	1.12
Robust standard error	Yes	Yes	Yes	Yes
R^2	31%	26%	27%	27%
N	15,435	17,411	18,633	23,802

Note: $p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$
Source: authors' creation by using NIDS secure data and the Global Flood Database.

Tables 5 and 6 show the effects of floods on income with social benefits. Floods have a negative impact on income with social benefits particularly for individuals within 0.5 km of flood zones, with weaker but still significant effects up to 1 km away. While the country's extensive social grant system is a crucial safety net, floods disrupt both access to and the effectiveness of these transfers (David et al. 2025). Damaged infrastructure, displacement of households, and loss of identity documents often delay or prevent the receipt of payments (the latter is seen as key to contributing to the psychological impact of floods (Khandlhela and May 2006)). Payment points such as post offices, banks, and retail outlets may also be inaccessible due to road damage or power outages. At the same time, many households exposed to floods fall outside grant eligibility criteria, particularly unemployed adults without children, informal workers, and migrants (David et al. 2025).

The absence of shock-responsive or temporary benefits means that, during disasters, social transfers do not expand to meet the increased need, leaving many affected households without additional support. Even when social benefits are received, their value may be diminished in the aftermath of floods if local inflation in food, fuel, and housing repair costs reduces the real purchasing power of fixed-value grants (Kabundi et al. 2022), while households often have to divert benefits away from regular needs such as food, school fees, or healthcare to cover flood-related expenses like home repairs or temporary shelter (Yan, 2025). These pressures reduce the welfare-enhancing role of social transfers at precisely the time they are most critical. Spill-over effects into nearby areas also weaken the effectiveness of grants, as rising prices and disrupted markets erode their impact. As a result, floods undermine the stabilising role of social benefits, leaving poor households more exposed to deprivation and inequality.

Table 5: Effect of floods on income with social benefits, 0.5km radius

	Wave 1	Wave 2	Wave 3	Wave 5
Floods	-146***	-98**	-215***	-420***
Pop. group				
Black	0.00	0.00	0.00	0.00
Coloured	145***	226***	160***	15
Asian/Indian	2,153***	1,982***	3,096***	2,538***
White	5,164***	5,586***	6,305***	1,0916***
Other	-	3910*	-	7,546**
Education	110***	91***	121***	21***
Gender				
Male	0.00	0.00	0.00	0.00
Female	-190***	-199***	-293***	-562***
Age	17***	15***	19***	32***
Work status				
Unemployed	0.00	0.00	0.00	0.00
Employed	1,081 ***	1,112***	1,236***	2,013***
Casual worker	254 ***	89	98	74
Self-employed	646***	749***	921 ***	2,233***

Variance Inflation Factors (VIF)	1.17	1.12	1.14	1.13
Robust standard error	Yes	Yes	Yes	Yes
R^2	30%	26%	26%	27%
N	15,435	17,411	18,633	23,802

Note: $p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$
Source: authors' creation by using NIDS secure data and the Global Flood Database.

Table 6: Effect of floods on income with social benefits, 0.6-1km radius

	Wave 1	Wave 2	Wave 3	Wave 5
Floods	-101***	-61**	-119***	-141***
Pop. group				
Black	0.00	0.00	0.00	0.00
Coloured	168***	242***	193***	217**
Asian/Indian	2183***	1992***	3138***	2517***
White	5,167 ***	5,592 ***	6,314***	10,938***
Other	-	3906.57*	-	7,628***
Education	110 ***	91 ***	121***	214. ***
Gender				
Male	0.00	0.00	0.00	0.00
Female	-191***	-201***	-295***	-567***
Age	17***	15***	19***	32***
Work status				
Unemployed	0.00	0.00	0.00	0.00
Employed	1,083***	1,114***	1,240***	2,021***
Casual worker	258***	89	88	88
Self-employed	644***	754.***	919***	2,240***
Variance Inflation Factors (VIF)	1.17	1.12	1.14	1.12
Robust standard error	Yes	Yes	Yes	Yes
R^2	30%	26%	26%	27%
N	15,435	17,411	18,633	23,802

Note: $p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$
Source: authors' creation by using NIDS secure data and the Global Flood Database.

Tables 7 and 8 report the effects of floods on post-fiscal income. Floods reduce post-fiscal income by undermining both market earnings from (self) employment and the redistributive impact of the fiscal system. On the market side, floods destroy jobs, productive assets, and disrupt informal trading opportunities and locations, which form the backbone of livelihoods for poorer individuals. In South Africa, where a significant share of the population depends on vulnerable informal work, floods severely constrain labour income and household production. These immediate shocks to employment and capital naturally create a lower baseline from which the fiscal system operates. While social grants, pensions, and other transfers are in place, they are rarely designed to expand quickly in response to climate shocks (see similar negative effects discussed in Tables 5 and 6), and there is evidence that their disbursement is fraught with coordination challenges (Khandlhela and May 2006) and inequality in disbursement may exacerbate social tensions (World Bank 2022). As a result, the decline in market incomes is only partially cushioned, leaving individuals poorer even after taxes are incorporated.

The fiscal system itself compounds this decline in four important ways. First, coverage gaps leave many workers, particularly informal labourers and migrants, outside the scope of unemployment insurance or emergency relief. Second, the real value of transfers erodes after floods, as disasters often trigger inflation in food and energy markets (Kabundi et al. 2022), reducing the purchasing power of fixed benefits. Third, indirect taxes such as VAT and excises continue to burden individuals, disproportionately affecting the poor who spend most of their income on taxed essentials (even in the presence of tax exemptions). Even if some specific products might be temporarily exempt from VAT (businesses also typically benefit from corporate tax suspensions during periods of crises), the fact indirect taxes are embedded into prices means flood victims still bear the incidence of the taxes.Finally, disaster relief spending tends to be slow and infrastructure-focused rather than individual-targeted, meaning direct compensation is limited.

Table 7: Effect of floods on post fiscal income, 0.5km radius.

	Wave 1	Wave 2	Wave 3	Wave 5
Floods	-131***	-39.	92	-275**
Pop. group				
Black	0.00	0.00	0.00	0.00
Coloured	-77*	228***	74	191
Asian/Indian	414***	2014***	4,730***	2,042***
White	2,602***	4,379***	4,857***	8,798***
Other	-	-1,030	-	3,829
Education	46***	73***	108***	178***
Gender				
Male	0.00	0.00	0.00	0.00
Female	-111***	-197***	-210***	-535***
Age	6***	9***	17***	23***
Work status				
Unemployed	0.00	0.00	0.00	0.00
Employed	683***	927***	1138***	1877***
Casual worker	-0.93	-114	-90	-19
Self-employed	316***	783***	687***	1759***
Variance Inflation Factor (VIF)	1.17	1.12	1.14	1.12
Robust standard error	Yes	Yes	Yes	Yes
R^2	18%	9%	10%	14%
N	15,430	17,412	18,631	23,801

Note: $p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Source: authors' creation by using NIDS secure data and the Global Flood Database.

Table 8: Effect of floods on post fiscal income, 0.6-1km radius.

	Wave 1	Wave 2	Wave 3	Wave 5
Floods	-36*	-71*	-90**	-50
Pop. group				
Black	0.00	0.00	0.00	0.00
Coloured	-60	237***	68	230*
Asian/Indian	419***	2,037***	4,785***	2,024***
White	2,608***	4,379***	4,845***	8,820***
Other	-	-1,040	-	3,880
Education	47***	72***	107***	179***
Gender				
Male	0.00	0.00	0.00	0.00
Female	-113***	-197***	-207***	-539***
Age	7***	9***	16***	23***

Work status				
Unemployed	0.00	0.00	0.00	0.00
Employed	688***	927***	1,134***	1,881***
Casual worker	3	927***	-89	-10
Self-employed	319***	784***	671***	1,765***
Variance Inflation factor (VIF)	1.17	1.12	1.14	1.12
Robust standard error	Yes	Yes	Yes	Yes
R^2	18%	9%	10%	14%
N	15,430	17,412	18,631	23,801

Note: $p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$
Source: authors' creation by using NIDS secure data and the Global Flood Database.

Floods also reduce consumption by simultaneously reducing purchasing power and raising the costs of essential goods and services (Tables A7 and A8 in the Appendix). Individuals living within 0.5 km of flood zones face the sharpest effects, as labour income losses and the destruction of productive assets quickly constrain their ability to buy food and non-food items (Arouri et al. 2015; Baez et al. 2020; Justino et al. 2025; Santoro and Santos 2020; World Bank 2022). Food consumption declines both in quantity and quality: crops and livestock are destroyed, supply chains disrupted, and local markets destabilised, driving up food prices and forcing poor households to shift to cheaper staples or reduce dietary diversity (Tidiane Ndour et al. 2025).

Non-food consumption is also constrained as floods damage housing and household assets, compelling families to divert scarce resources toward repairs or replacements rather than everyday spending. At the same time, floods increase the cost of non-food essentials, further squeezing household budgets (Yan 2025). Utilities such as water, electricity, and sanitation are often disrupted, forcing reliance on costly substitutes. These pressures crowd out food spending and further heighten deprivation (Tables A9 and A10 show the effects of floods on material deprivation). Importantly, the adverse impacts extend up to 1 km beyond directly affected areas through spill-over channels such as disrupted infrastructure networks, reduced market availability, and inflationary effects on food and fuel (Azzarri and Signorelli 2020; Shifa et al. 2023). In South Africa's context, where poor households already spend a large share of income on food and basic services, flood-induced shocks to consumption reinforce vulnerability and deepen inequality.

The robustness analysis using the IPUMS-based flood variable for 2011 reinforces the main findings by demonstrating that floods significantly reduce individual income even under an alternative empirical specification. Although the variable is limited to a single year and reflects conditions before or during the February 2011 floods, the multilevel regression results consistently show negative effects of floods on monthly individual income. This strengthens confidence in the causal relationship between flood exposure and income loss, suggesting that the adverse impacts are not an artefact of measurement or data choice. Importantly, the persistence of significant results under a different dataset and methodology highlights the robustness of the link between floods and individual welfare in South Africa, while also underlining the vulnerability of labour markets to environmental disasters. Despite the temporal limitation, the IPUMS analysis confirms that floods have a measurable and detrimental impact on income.

In summary, the findings highlight that floods in South Africa are not only environmental shocks but also drivers of inequality. They reduce incomes (hence consumption), undermine redistributive systems and heighten material deprivation. In addition, flood-induced erosion of monetary and non-monetary conditions is not evenly distributed, and the burden falls disproportionately on poorer individuals. In line with previous studies, we find that low-income families are more likely to reside in flood-prone areas and are less able to recover due to limited access to finance (i.e., insurance or credit) and they tend to have less savings as well (Hallegatte et al. 2020; Dlamini et al. 2024; Vin et al. 2025). Even in cases where richer and poorer individuals experience the same shocks, wealthier groups can mitigate losses by replacing goods, relocating temporarily, or absorbing higher prices, while poorer individuals face lasting material deprivation. Beyond the immediate flood zone, inequalities widen further as affluent individuals adapt to disrupted markets and services, while low-income neighbours fall deeper into hardship. Thus, floods both intensify absolute deprivation and sharpen relative inequality, reinforcing pre-existing socioeconomic divides. Analysing these dynamics is essential for informing policy responses that move beyond short-term relief toward long-term resilience. Without such measures, climate change will continue to entrench inequality, leaving poor individuals consistently further behind. With them, however, South Africa and other countries facing similar challenges, can turn adaptation into an opportunity to build more equitable and resilient societies.

6 Conclusion

This paper set out to answer the primary research question: how do floods impact inequality in South Africa? By linking georeferenced flood data with cross sectional data from the National Income Dynamics Study (NIDS) dataset and applying a DiD analysis, we have been able to estimate the causal effects of flood exposure on a range of income and welfare outcomes. The results reveal a consistent pattern: floods have a significant impact across both high-intensity exposure and low-intensity exposure individuals, reducing labour income, income with social benefits, and post-fiscal income, while also lowering individual consumption and increasing material deprivation. These findings point to the multifaceted ways in which climate-related disasters amplify inequality, affecting both market and non-market dimensions of household welfare (Shifa et al. 2023).

The evidence is particularly stark for labour income. People located within 0.5 km of flood zones experience the largest losses, as floods destroy workplaces, disrupt transport links, and undermine informal markets where many South Africans earn their livelihoods. These effects also extend up to 1 km away, albeit more weakly, through spill-over channels such as weakened demand, damaged infrastructure, and disrupted supply chains. In a context where informal and vulnerable employment is widespread, these labour income shocks translate directly into heightened economic insecurity and diminished resilience. When considering post-fiscal income, the analysis underscores the limitations of South Africa's fiscal system in mitigating disaster-related shocks. Although social grants and transfers cushion some losses, they are not sufficiently shock-responsive. Gaps in coverage exclude informal workers and migrants, while fixed grant values are quickly eroded by post-disaster inflation, especially in food and fuel markets. Furthermore, the persistence of indirect taxes, such as VAT and excises, continues to reduce disposable resources even when individual earnings decline (although government policies can also temporarily suspend these taxes). As a result, individuals' post-fiscal income falls substantially after floods, highlighting the difficulty of relying on existing redistributive instruments to counteract climate shocks.

The effects on individual consumption and material deprivation provide an additional perspective on inequality. Floods reduce people's ability to meet daily needs by simultaneously lowering incomes and raising living costs. Homes and durable goods are destroyed, food and energy prices rise, and access to water, electricity, and sanitation is frequently disrupted. These shocks increase material deprivation, with the sharpest effects occurring in flood zones but with spill-over into surrounding areas. Such findings are critical because they reveal that floods affect not only financial resources but also broader dimensions of human well-being, such as health, education, and living conditions (Shifa et al. 2023). In a society where deprivation remains widespread and structural inequality entrenched; these outcomes reinforce long-term disadvantage.

It is crucial to conduct this type of analysis in South Africa because the country represents a particularly acute case of disaster-inequality dynamics. South Africa is one of the most unequal societies in the world, with a persistently high Gini coefficient, widespread unemployment, and deeply racialised patterns of spatial settlement. Many low-income households are forced to reside in informal settlements or inadequately serviced urban peripheries that are highly exposed to flood risk. The convergence of climate change, rapid urbanisation, and weak infrastructure means that flood events are becoming both more frequent and more damaging. Without empirical analysis of how floods intersect with inequality, there is a risk that policy responses will remain reactive and inadequate, leaving the most vulnerable populations further behind. Understanding these dynamics also provides a basis for designing adaptation and social protection policies that are equitable and inclusive, rather than exacerbating pre-existing disparities.

The policy implications of these findings are clear. First, strengthening the resilience of labour markets is critical, particularly for informal workers and small businesses that form the backbone of livelihoods in flood-prone areas. Targeted support, such as emergency wage subsidies, microfinance for rebuilding, and rapid infrastructure repair, could help protect labour income in the aftermath of disasters (David et al., 2025). Second, South Africa's social protection system should be made more shock-responsive. This could include temporary top-ups to grants during crises, expanding coverage to informal workers, and indexing benefits to inflation. Third, investment in resilient infrastructure and essential services is essential to reduce material deprivation during and after floods (Justino et al. 2025; IMF, 2016). This includes upgrading drainage, water, sanitation, and energy systems in vulnerable communities, while also addressing the long-standing housing backlogs that force households into high-risk locations. Finally, fiscal policy should aim to reduce the regressive burden of indirect taxation on poor individuals during crises, for instance through temporary VAT exemptions on essential goods.

References

Akther, Hasina, and Mokbul Morshed Ahmad. 2022. 'Livelihood in the Pluvial Flood Prone Slum Communities in Dhaka, Bangladesh'. *Progress in Disaster Science* 14 (April): 100227. https://doi.org/10.1016/j.pdisas.2022.100227.

Azzarri, C., and Signorelli, S. (2020). Climate and poverty in Africa South of the Sahara. *World development*, *125*, 104691.

Baez, J. E., Caruso, G., and Niu, C. (2020). Extreme weather and poverty risk: Evidence from multiple shocks in Mozambique. *Economics of Disasters and Climate Change*, *4*(1), 103-127.

Bangalore, Mook, Andrew Smith, and Ted Veldkamp. 2019. 'Exposure to Floods, Climate Change, and Poverty in Vietnam'. *Economics of Disasters and Climate Change* 3 (1): 79–99. https://doi.org/10.1007/s41885-018-0035-4.

Bouchard, J. P., Pretorius, T. B., Kramers-Olen, A. L., Padmanabhanunni, A., and Stiegler, N. (2023, March). Global warming and psychotraumatology of natural disasters: The case of the deadly rains and floods of April 2022 in South Africa. In *Annales Médico-psychologiques, revue psychiatrique* (Vol. 181, No. 3, pp. 234-239). Elsevier Masson.

Branson, Nicola, Johs Hjellbrekke, Murray Leibbrandt, Vimal Ranchhod, Mike Savage, and Emma Whitelaw. 2024. 'The Socioeconomic Dimensions of Racial Inequality in South Africa: A Social Space Perspective'. *The British Journal of Sociology* n/a (n/a). https://doi.org/10.1111/1468-4446.13115.

Cappelli, F., Costantini, V., & Consoli, D. (2021). The trap of climate change-induced "natural" disasters and inequality. *Global Environmental Change*, *70*, 102329.

Cutter, Susan L., Bryan J. Boruff, and W. Lynn Shirley. 2003. 'Social Vulnerability to Environmental Hazards'. *Social Science Quarterly* 84 (2): 242–61. https://doi.org/10.1111/1540-6237.8402002.

Dartmouth Flood Observatory. (2021). *Global Flood Database v1 (2000–2018)* [Data set]. Google Earth Engine. Retrieved from Global Flood Database

Davenport, F. V., Burke, M., & Diffenbaugh, N. S. (2021). Contribution of historical precipitation change to US flood damages. *Proceedings of the National Academy of Sciences*, *118*(4), e2017524118.

David, A., M. Leibbrandt, H. Djoufelkit, and R. Yasser (2025). 'Climate Change, Poverty Reduction, and Inequality between and within Countries'. In A. David, M. Leibbrandt, V. Ranchhod, and R. Yasser (eds), *Inequalities in Sub-Saharan Africa: Multidimensional Perspectives and Future Challenges*. Washington, DC: International Bank for Reconstruction and Development/World Bank. http://hdl.handle.net/10986/42457

De Silva, M. M. G. T., and Akiyuki Kawasaki. 2018. 'Socioeconomic Vulnerability to Disaster Risk: A Case Study of Flood and Drought Impact in a Rural Sri Lankan Community'. *Ecological Economics* 152 (October): 131–40. https://doi.org/10.1016/j.ecolecon.2018.05.010.

Díaz Pabón, Fabio Andrés, Muna Shifa, Vimal Ranchhod, and Takwanisa Machemedze. 2024. 'Climate Change-Related Shocks, Assets and Welfare Outcomes in South Africa'. *South African Journal of Economics* 92 (1): 93–104. https://doi.org/10.1111/saje.12368.

Dlamini, Simangele, Bathabile Nhleko, and Nomcebo Ubisi. 2024. 'Understanding Socioeconomic Risk and Vulnerability to Climate Change–Induced Disasters: The Case of Informal Settlements in KwaZulu-Natal, South Africa'. *Journal of Asian and African Studies*, September 9, 00219096241275398. https://doi.org/10.1177/00219096241275398.

Dorland, C., M.A. van Drunen, and P.E. van der Werff. 2003. *Poverty and Climate Change: Reducing the Vulnerability of the Poor through Adaptation*. The World Bank.

Elliott, James R., and Jeremy Pais. 2006. 'Race, Class, and Hurricane Katrina: Social Differences in Human Responses to Disaster'. *Social Science Research*, Katrina in New Orleans/Special Issue on Contemporary Research on the Family, vol. 35 (2): 295–321. https://doi.org/10.1016/j.ssresearch.2006.02.003.

Fielding, Jane, and Kate Burningham. 2005. 'Environmental Inequality and Flood Hazard'. *Local Environment* 10 (4): 379–95. https://doi.org/10.1080/13549830500160875.

GDACS. 2025. 'Overall Green Flood Alert in South Africa from 17 Feb 2025 01:00 UTC to 15 Mar 2025 01:00 UTC'. https://www.gdacs.org/report.aspx?eventtype=FL&eventid=1103129.

Govender, Indrani Hazel, Maliga Reddy, Rajendran Perumal Pillay, Indrani Hazel Govender, Maliga Reddy, and Rajendran Perumal Pillay. 2025. 'A Review of Residual Flood Risks in South African-Vulnerable Coastal Communities: Opportunities to Influence Policy'. In *Climate Policies - Modern Risk-Based Assessment of Investments in Mitigation, Adaptation, and Recovery from Residual Harm*. IntechOpen. https://doi.org/10.5772/intechopen.1008977.

Government, South Africa. 2025. 'Treasury on Enhancing South Africa's Approach to Disaster Risk Insurance | South African Government'. August 1. https://www.gov.za/news/media-statements/treasury-enhancing-south-africa%E2%80%99s-approach-disaster-risk-insurance-01-aug.

Hallegatte, Stéphane, Adrien Vogt-Schilb, Julie Rozenberg, Mook Bangalore, and Chloé Beaudet. 2020. 'From Poverty to Disaster and Back: A Review of the Literature'. *Economics of Disasters and Climate Change* 4 (1): 223–47. https://doi.org/10.1007/s41885-020-00060-5.

Harrison, Philip Todes. 2016. *SPATIAL CONSIDERATIONS IN THE DEVELOPMENT OF URBAN POLICY IN SOUTH AFRICA: A RESEARCH PAPER AS INPUT INTO THE PREPARATION OF THE INTEGRATED URBAN DEVELOPMENT FRAMEWORK (IUDF)*. https://hdl.handle.net/10539/38438.

Haskoning. 2021. 'Flood Risk Assessment for South African Townships'. Haskoning. https://www.haskoning.com/en/projects/flood-risk-assessment-for-south-african-townships.

Hlahla, Sithabile, and Trevor R. Hill. 2018. 'Responses to Climate Variability in Urban Poor Communities in Pietermaritzburg, KwaZulu-Natal, South Africa'. *SAGE Open* 8 (3): 2158244018800914. https://doi.org/10.1177/2158244018800914.

Hossain, Babul, Md. Salman Sohel, and Crispin Magige Ryakitimbo. 2020. 'Climate Change Induced Extreme Flood Disaster in Bangladesh: Implications on People's Livelihoods in the Char Village and Their Coping Mechanisms'. *Progress in Disaster Science* 6 (April): 100079. https://doi.org/10.1016/j.pdisas.2020.100079.

IPCC. 2001. *Vulnerability to Climate Change and Reasons for Concern: A Synthesis — IPCC.* https://www.ipcc.ch/report/ar3/wg2/chapter-19-vulnerability-to-climate-change-and-reasons-for-concern-a-synthesis/.

Jewkes, R., A. Gibbs, S. Mkhwanazi, et al. 2023. 'Impact of South Africa's April 2022 Floods on Women and Men's Lives and Gender Relations in Low-Income Communities: A Qualitative Study'. *SSM - Mental Health* 4 (December): 100255. https://doi.org/10.1016/j.ssmmh.2023.100255.

Kabundi, A., M. Mlachila, and J. Yao (2022). 'How Persistent Are Climate-Related Price Shocks?' IMF Working Paper 22/207. Washington, DC: IMF. https://doi.org/10.5089/9798400223556.001

Kawasaki, Akiyuki, and Natsumi Shimomura. 2024. 'Accelerated Widening of Economic Disparity Due to Recurrent Floods'. *International Journal of Disaster Risk Reduction* 102 (February): 104273. https://doi.org/10.1016/j.ijdrr.2024.104273.

Kergozou, Nikki. 2025. 'Supporting Climate-Change Mitigation and Adaptation'. OECD, June 5. https://www.oecd.org/en/publications/oecd-economic-surveys-south-africa-2025_7e6a132a-en/full-report/supporting-climate-change-mitigation-and-adaptation_21950515.html.

Khandlhela, M., & May, J. (2006). Poverty, vulnerability and the impact of flooding in the Limpopo Province, South Africa. *Natural Hazards*, *39*(2), 275-287.

Leibbrandt, Murray, Arden Finn, and Ingrid Woolard. 2012. 'Describing and Decomposing Post-Apartheid Income Inequality in South Africa'. *Development Southern Africa* 29 (1): 19–34. https://doi.org/10.1080/0376835X.2012.645639.

Leibbrandt, Murray, Ingrid Woolard, and Christopher Woolard. 2007. *Poverty and Inequality Dynamics in South Africa: Post-Apartheid Developments in the Light of the Long-Run Legacy*. 51.

Lindersson, Sara, Elena Raffetti, Maria Rusca, Luigia Brandimarte, Johanna Mård, and Giuliano Di Baldassarre. 2023. 'The Wider the Gap between Rich and Poor the Higher the Flood Mortality'. *Nature Sustainability* 6 (8): 995–1005. https://doi.org/10.1038/s41893-023-01107-7.

Linnerooth-Bayer, Joanne, and Stefan Hochrainer-Stigler. 2015. 'Financial Instruments for Disaster Risk Management and Climate Change Adaptation'. *Climatic Change* 133 (1): 85–100. https://doi.org/10.1007/s10584-013-1035-6.

Marutlulle, Noah K. 2021. 'A Critical Analysis of Housing Inadequacy in South Africa and Its Ramifications'. *Africa's Public Service Delivery & Performance Review* 9 (1): 16. https://doi.org/10.4102/apsdpr.v9i1.372.

Matladi, Tshedza. 2025. 'South Africa's Recent Floods: Is Climate Change to Blame?' Climate Change Writers. https://www.climatechangewriters.com/stories/south-africas-recent-floods-is-climate-change-to-blame.

Morrow, Betty Hearn. 2002. 'Identifying and Mapping Community Vulnerability'. *Disasters* 23 (1): 1–18. https://doi.org/10.1111/1467-7717.00102.

Musyoki, Agnes, Reuben Thifhulufhelwi, and Florence M. Murungweni. 2016. 'The Impact of and Responses to Flooding in Thulamela Municipality, Limpopo Province, South Africa'. *Jàmbá : Journal of Disaster Risk Studies* 8 (2): 166. https://doi.org/10.4102/jamba.v8i2.166.

PricewaterhouseCoopers. 2025. 'South Africa Economic Outlook - March 2025 | Press Release'. PwC. https://www.strategyand.pwc.com/a1/en/press-release/south-africa-economic-outlook-march-2025.html.

Ratnadiwakara, Dimuthu, and Buvaneshwaran Venugopal. 2020. 'Do Areas Affected by Flood Disasters Attract Lower-Income and Less Creditworthy Homeowners?' *Journal of Housing Research* 29 (sup1): S121–43. https://doi.org/10.1080/10527001.2020.1840246.

Ruggles, S., Cleveland, L. L., Lovatón Dávila, R., Sarkar, S., Sobek, M., Burk, D., Ehrlich, D. E., Heimann, Q., Lee, J., & Merrill, N. (2025). *IPUMS International: Version 7.6* [Dataset]. Minneapolis, MN: IPUMS. https://doi.org/10.18128/D020.V7.6

Salvucci, V., and Santos, R. (2020). Vulnerability to natural shocks: Assessing the short-term impact on consumption and poverty of the 2015 flood in Mozambique. *Ecological Economics*, *176*, 106713.

Shifa, Muna, Murray Leibbrandt, and David Gordon. 2023. 'Profiling Multidimensional Climate-Related Vulnerability in South Africa'. TSITICA Working paper. https://www.researchgate.net/profile/Muna-Shifa/publication/388674471_PROFILING_MULTIDIMENSIONAL_CLIMATE-RELATED_VULNERABILITY_IN_SOUTH_AFRICA_Profiling_Multidimensional_Climate-Related_Vulnerability_in_South_Africa/links/67a1d9d552b58d39f26ae8b6/PROFILING-MULTIDIMENSIONAL-CLIMATE-RELATED-VULNERABILITY-IN-SOUTH-AFRICA-Profiling-Multidimensional-Climate-Related-Vulnerability-in-South-Africa.pdf.

Southern Africa Labour and Development Research Unit. National Income Dynamics Study Wave 1 2008, Secure Data [dataset]. Version 7.0.0. Pretoria: SA Presidency [funding agency]. Cape Town: Southern Africa Labour and Development Research Unit [implementer], 2018. Cape Town: DataFirst [distributor], 2018. https://doi.org/10.25828/jnkz-s804

Southern Africa Labour and Development Research Unit. National Income Dynamics Study Wave 2, 2010-2011 Secure Data [dataset]. Version 4.0.0. Pretoria: SA Presidency [funding agency]. Cape Town: Southern Africa Labour and Development Research Unit [implementer], 2018. Cape Town: DataFirst [distributor], 2018. https://doi.org/10.25828/sx6m-k709

Southern Africa Labour and Development Research Unit. National Income Dynamics Study Wave 3, 2012, Secure Data [dataset]. Version 3.0.0. Pretoria: SA Presidency [funding agency]. Cape Town: Southern Africa Labour and Development Research Unit [implementer], 2018. Cape Town: DataFirst [distributor], 2018. https://doi.org/10.25828/262r-8n47

Southern Africa Labour and Development Research Unit. National Income Dynamics Study 2017, Wave 5, Secure Data [dataset]. Version 1.0.0 Pretoria: Department of Planning, Monitoring, and Evaluation [funding agency]. Cape Town: Southern Africa Labour and

Development Research Unit [implementer], 2018. Cape Town: DataFirst [distributor], 2018. https://doi.org/10.25828/v7qp-qk09

Tidiane Ndour, C., Diop, W., and Asongu, S. (2025). The effect of natural disasters on food security in Sub-Saharan Africa. *Social Responsibility Journal*, *21*(1), 180-197.

Tovar Reaños, Miguel A. 2021. 'Floods, Flood Policies and Changes in Welfare and Inequality: Evidence from Germany'. *Ecological Economics* 180 (February): 106879. https://doi.org/10.1016/j.ecolecon.2020.106879.

Vin, Leon, and Akiyuki Kawasaki. 2024. 'Do Floods Widen the Economic Disparity Gap?' *Progress in Disaster Science* 24 (December): 100362. https://doi.org/10.1016/j.pdisas.2024.100362.

Vin, Leon, Akiyuki Kawasaki, and Sutee Anantsuksomsri. 2025. 'How Recurrent Floods Create Inequality in Livelihood Improvement through Education'. *Humanities and Social Sciences Communications* 12 (1): 618. https://doi.org/10.1057/s41599-025-04942-5.

Winsemius, Hessel C., Jeroen C. J. H. Aerts, Ludovicus P. H. van Beek, et al. 2016. 'Global Drivers of Future River Flood Risk'. *Nature Climate Change* 6 (4): 381–85. https://doi.org/10.1038/nclimate2893.

Winsemius, H. C., Jongman, B., Veldkamp, T. I., Hallegatte, S., Bangalore, M., and Ward, P. J. (2018). Disaster risk, climate change, and poverty: assessing the global exposure of poor people to floods and droughts. *Environment and Development Economics*, *23*(3), 328-348.

Yamamura, Eiji. 2015. 'The Impact of Natural Disasters on Income Inequality: Analysis Using Panel Data during the Period 1970 to 2004'. *International Economic Journal* 29 (3): 359–74. https://doi.org/10.1080/10168737.2015.1020323.

Yan, J. (2025). Abnormal Weather and Household Consumption. *Review of Development Economics*. 1-4.

Zhou, L., Kori, D. S., Sibanda, M., & Nhundu, K. (2022). An analysis of the differences in vulnerability to climate change: A review of rural and urban areas in South Africa. *Climate*, *10*(8), 118.

APPENDIX

Table A1: Income and consumption sources

Variable	Definition	Notes and Outlier Treatment
Labour income (without grants)	Sum of wage income, business/self-employment income, remittances, property income.	Divided by household size; values ≥ 1,000,000 recoded to missing before top-coding; per-capita measure constructed. Negative values replaced with zero.
Income with social benefits (total income with grants)	Labour income components + social grants and transfers.	Divided by household size; values ≥ 1,000,000 recoded to missing before top-coding; per-capita measure constructed. Negative values replaced with zero.
Post-fiscal income	Household disposable income after taxes.	Divided by household size; values ≥ 1,000,000 recoded to missing; thresholds applied by wave: e.g., >50,000 (W1), >100,000 (W2), >600,000 (W3), >800,000 (W5). Negative values replaced with zero.
Consumption	Sum of household expenditure items (h_*spn variables for food, utilities, transport, etc.)	Negative values replaced with zero; totals divided by household size to obtain per-capita consumption.

Source: authors' creation by using NIDS secure data and the Global Flood Database.

Table A2: Deprivation index

Dimension	Questionnaire Label	Coding Rule
Wall material	Main material of dwelling walls	Deprived if walls are made of mud, cardboard, or other rudimentary materials. Not deprived if walls are made of brick, block, concrete, or other durable materials.
Source of water	Main source of drinking water	Deprived if household relies on public tap, borehole, well, river/stream, vendor, tanker, or other unimproved source. Not deprived if water is piped into dwelling or yard.

Type of toilet	Type of toilet used by household	Deprived if household uses pit latrine without ventilation, bucket toilet, or has no toilet. Not deprived if household uses flush toilet to sewer or septic.
Cooking fuel	Main fuel used for cooking	Deprived if household uses wood, coal, dung, crop residue, candles, or other solid fuels. Not deprived if household uses electricity, gas, or paraffin.
Heating source	Main source of energy for heating	Deprived if household uses wood, coal, dung, none, or other unimproved sources. Not deprived if household uses electricity, gas, or paraffin.
Lighting source	Main source of lighting	Deprived if household uses candles, paraffin, wood, generator, none, or other unimproved sources. Not deprived if household uses electricity.
Telephone (landline)	Household has a working landline	Deprived if household has no access or a disconnected landline. Not deprived if household has a working landline.
Mobile phone	Household has access to a mobile phone	Deprived if household has no access to a mobile phone. Not deprived if household has access to a mobile phone.
Waste disposal	How household waste is disposed	Deprived if waste is dumped, burned, or not removed. Not deprived if waste is removed weekly or less often by authorities/private companies.
Street lights	Are there working street lights in the area?	Deprived if street lights are absent or broken. Not deprived if street lights are present and functional.

Source: authors' creation by using NIDS secure data.

Table A3: Summary statistics, Wave 1

	Mean	sd	Min	Max	Count
Flood 0.5km radius	0.13	0.34	0.00	1.00	59,677.00
Flood 1km radius	0.21	0.62	0.00	2.00	59,677.00
Labour income	988.06	2,513.24	0.00	93,800.00	28,226.00
Income with social benefits	1,126.38	2,488.34	0.00	93,800.00	28,226.00
Post fiscal income	574.06	1,672.31	0.00	50,000.00	28,221.00
Population group	1.35	0.78	1.00	4.00	15,595.00
Education	7.78	4.02	0.00	40.00	15,525.00
Gender	1.60	0.49	1.00	2.00	15,631.00
Age	27.23	20.62	0.00	105.00	28,159.00
Work status	1.49	0.82	1.00	4.00	15,591.00

Source: authors' creation by using NIDS secure data.

Table A4: Summary statistics, Wave 2

	Mean	sd	Min	Max	Count
Flood 0.5km radius	0.15	0.36	0.00	1.00	59,677.00
Flood 1km radius	0.25	0.66	0.00	2.00	59,677.00
Labour income	843.17	2,271.72	0.00	98,535.16	29,661.00
Income with social benefits	983.01	2,255.33	0.00	98,535.16	29,661.00
Post fiscal income	770.31	3,208.91	0.00	166,666.67	29,581.00
Population group	1.24	0.66	0.00	5.00	17,623.00
Education	8.00	4.06	0.00	40.00	17,541.00
Gender	1.59	0.49	1.00	2.00	17,617.00
Age	27.01	20.24	0.00	104.00	34,228.00
Work status	1.39	0.71	1.00	4.00	17,488.00

Source: authors' creation by using NIDS secure data.

Table A5: Summary statistics, Wave 3

	Mean	sd	Min	Max	Count
Flood 0.5km radius	0.14	0.35	0.00	1.00	59,677.00
Flood 1km radius	0.24	0.65	0.00	2.00	59,677.00
Labour income	1,069.79	25,82.43	0.00	85,000.00	33,223.00
Income with social benefits	1,254.46	25,60.96	0.00	85,000.00	33,223.00
Post fiscal income	1,013.85	3,505.65	0.00	250,000.00	33,219.00
Population group	1.24	0.61	1.00	4.00	18,689.00
Education	8.25	3.87	0.00	40.00	18,671.00
Gender	1.60	0.49	1.00	2.00	18,689.00
Age	27.12	20.25	0.00	105.00	37,491.00
Work status	1.44	0.75	1.00	4.00	18,653.00

Source: authors' creation by using NIDS secure data.

Table A6: Summary statistics, Wave 5

	Mean	sd	Min	Max	Count
Flood 0.5km radius	0.13	0.33	0.00	1.00	59,677.00
Flood 1km radius	0.21	0.62	0.00	2.00	59,677.00
Labour income	2,085.42	51,28.91	0.00	209,000.00	40,941.00
Income with social benefits	2,322.79	50,88.93	0.00	209,000.00	40,941.00
Post fiscal income	1966.37	6051.10	0.00	600,000.00	40,937.00
Population group	1.32	0.74	1.00	5.00	23,891.00
Education	9.04	3.67	0.00	40.00	23,861.00
Gender	1.59	0.49	1.00	2.00	23,892.00
Age	28.19	20.62	0.00	111.00	46,973.00
Work status	1.51	0.79	1.00	4.00	23,826.00

Source: authors' creation by using NIDS secure data.

Table A7: Consumption, 0.5 km radius

	Wave 1	Wave 2	Wave 3	Wave 5
Floods	-146***	-118***	-125***	-375***
Pop. group				
Black	0.00	0.00	0.00	0.00
Coloured	82***	356***	91***	251***
Asian/Indian	2,582***	2,276***	2,734***	1,707***
White	4,072***	3,785***	4,051***	8,305***
Other	-	4,572***	-	849***
Education	86***	66***	91***	140***
Gender				
Male	0.00	0.00	0.00	0.00
Female	-87***	-108***	-143***	-364***
Age	10***	8***	13***	19***
Work status				
Unemployed	0.00	0.00	0.00	0.00
Employed	537***	534***	634***	1,002***
Casual work	13	14	90	-129
Self-employed	638***	462***	640***	1,778***
N	15,432	17,413	18,633	23,798
R^2	28%	13%	18%	19%
Variance Inflation Factors (VIF)	1.17	1.12	1.14	1.12
Robust standard error	Yes	Yes	Yes	Yes

Note: $p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$

Source: authors' creation by using NIDS secure data and the Global Flood Database.

Table A8: consumption, 0.6–1 km radius

	Wave 1	**Wave 2**	**Wave 3**	**Wave 5**
Floods	-66	-93***	-79***	-175***
Pop. group				
Black	0.00	0.00	0.00	0.00
Coloured	103***	376***	110***	308***
Asian/Indian	2,598***	2,297***	2,764***	1,694***
White	4,078***	3,791***	4,056***	8,316***
Other	-	4,564***	-	925***

Education	87***	66***	91***	150***
Gender				
Male	0.00	0.00	0.00	0.00
Female	-89***	-110***	-145***	-367***
Age	10***	9***	13***	19***
Work status				
Unemployed	0.00	0.00	0.00	0.00
Employed	540***	537***	636***	1,009***
Casual work	17	-58	-5	-116
Self-employed	639***	466***	638***	1,782***
N	15,432	17,413	18,633	23,798
R^2	27%	13%	18%	19%
Variance Inflation Factors (VIF)	1.17	1.12	1.14	1.12
Robust standard error	Yes	Yes	Yes	Yes

Note: $p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$
Source: authors' creation by using NIDS secure data and the Global Flood Database.

Table A9: Effect of floods on deprivation index, 0.5 km radius

	Wave 1	**Wave 2**	**Wave 3**	**Wave 5**
Floods	1.62***	1.51***	1.38***	0.97***
Pop. group				
Black	0.00	0.00	0.00	0.00
Coloured	-2.08***	-1.76***	-1.84***	-1.32***
Asian/Indian	-2.38***	-2.38***	-2.05***	-2.03***
White	-2.30***	-2.04***	-1.84***	-1.80***
Other		-1.67***		-1.92***
Education	-0.22***	-0.17***	-0.18***	-0.15***
Gender				
Male	0.00	0.00	0.00	0.00
Female	0.02	0.00	0.07***	0.06***
Age	-0.02***	-0.01***	-0.02***	-0.01***
Work status				
Unemployed	0.00	0.00	0.00	0.00
Employed	-0.55***	-0.63***	-0.58***	-0.42***
Casual work	-0.04	-0.23***	-0.34***	-0.20***
Self-employed	-0.25***	-0.12	-0.16*	0.07
N	14,542	16,502	17,746	22,762
R^2	34%	26%	27%	24%
Variance Inflation Factors (VIF)	1.17	1.12	1.14	1.13
Robust standard error	Yes	Yes	Yes	Yes

Note: $p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$
Source: authors' creation by using NIDS secure data and the Global Flood Database.

Table A10: Effect of floods on deprivation index, 0.6–1 km radius

	Wave 1	**Wave 2**	**Wave 3**	**Wave 5**
Floods	0.47***	0.43***	0.37***	0.26***
Pop. group				
Black	0.00	0.00	0.00	0.00
Coloured	-2.29***	-1.99***	-2.03***	-1.46***
Asian/Indian	-2.45***	-2.33***	-2.12***	-1.98***
White	-2.38***	-2.11***	-1.93***	-1.87***
Other	-	-1.77***	-	-2.11***
Education	-0.23***	-0.17***	-0.19***	-0.16***
Gender				
Male	0.00	0.00	0.00	0.00
Female	0.04	0.04	0.09***	0.07***
Age	-0.02***	-0.02***	-0.02***	-0.01***
Work status				
Unemployed	0.00	0.00	0.00	0.00
Employed	-0.61***	-0.58***	-0.10	0.03
Casual worker	-0.09	-0.18	-0.34***	-0.22***
Self-employed	-0.28***	-0.16*	-0.37***	-0.20***
N	14,542	16,502	17,746	22,762
R^2	31%	25%	24%	22%
Variance Inflation Factors (VIF)	1.17	1.12	1.14	1.12
Robust standard error	Yes	Yes	Yes	Yes

Note*:* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: authors' creation by using NIDS secure data and the Global Flood Database.

Table A11: Effects of floods on income

	(1)	(2)	(3)	(4)
Income				
Flood	-32934.026***	-19281.914***	-16676.826***	-18496.681***
Less than primary		0.000	0.000	0.000
Primary completed		1381.618***	1105.134***	4197.586***
Secondary		4797.060***	3241.587***	3558.993***
University		-46844.132***	-43164.751***	-35833.665***
Labour force (1 is inactive)		-4176.640***	-5370.228***	-16270.037***
Sex		1728.263***	1519.447***	3376.077***
Age		-938.119***	-826.920***	-733.766***
Race				
white		0.000	0.000	0.000
black african		-68594.505***	-37241.359***	-28786.488***
asian		-20845.527***	-19194.880***	-12544.758***
coloured		-40547.085***	-35420.746***	-32512.829***
other		-41111.716***	-23645.311***	-18743.090***
No disability			0.000	0.000

blind			-2141.996***	-3792.997***
deaf			-7593.802***	-8874.917***
mute			1273.430	-2573.018
mobility disability			-3592.828***	-7491.626***
Language spoken at home				
afrikaans			0.000	0.000
english			11508.828***	7475.180***
isindebele			-21331.600***	-13403.841***
isixhosa			-23281.977***	-25267.664***
isizulu			-20118.164***	-20104.416***
sepedi			-28176.291***	-23818.590***
sesotho			-23352.300***	-22048.400***
setswana			-26311.038***	-22292.923***
siswati			-24192.980***	-24889.816***
tshivenda			-29075.700***	-23454.158***
xitsonga			-30471.662***	-25084.990***
sign language			-6919.680***	-6866.407
other			-21098.358***	-17176.068***
Second language: speaks only one language			0.000	0.000
afrikaans			4052.178***	-882.783
english			6972.652***	5011.956***
isindebele			1017.290	1503.682
			(1160.270)	(2315.943)
isixhosa			-2857.336***	-5496.818***
isizulu			1248.048**	-2980.754***
sepedi			-2066.172**	-4588.686***
sesotho			1026.065	-2606.597*
setswana			-526.500	-5605.479***
siswati			-6164.555***	-7175.373***
tshivenda			3048.706*	-7106.750***
xitsonga			-4779.593***	-10003.702***
sign language			3504.692	7836.113
other			-6490.326***	-6336.207***
Migration status, previous residence				-368.456***
N	4,418,594	2,785,894	2,581,901	586,870

Note*:* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: authors' creation by using IPUMS (Ruggles et al., 2025) and the Global Flood Database.