TSITICA WORKING

PAPER NO 2

June 2023

CLIMATE SHOCKS AND HOUSEHOLD WELFARE: ASSESSING THE ROLE OF HOUSEHOLD ASSETS IN GHANA

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TSITICA Transforming Social Inequalities Through Inclusive Climate Action
ARUA-CD Centre of Excellence Climate and Development
UK Research and Innovation
ACDI African Climate & Development Initiative
University of East Anglia
ACEIR African Centre of Excellence for Inequality Research

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DISCLAIMER

All opinions, interpretations and conclusions expressed in this Transforming Social Inequalities through Inclusive Climate Action (TSITICA) Working Paper are entirely those of the authors and do not reflect the views of the research funder UK Research and Innovation (UKRI).

ACKNOWLEDGEMENTS

The Transforming Social Inequalities Through Inclusive Climate Action (TSITICA) project investigates how climate change action can be socially transformative in three contrasting African countries: Ghana, Kenya and South Africa. The research agenda addresses the nexus between climate change, sustainable livelihoods and multidimensional poverty and inequality to tackle the overall question: how can climate actions be deliberately targeted to improve livelihoods and lead to equitable benefits for the most vulnerable and poor – especially for women and youth? With the goal of inspiring climate actions that also reduce poverty and inequality, based on evidence and insights from the research, TSITICA aims to contribute the Agenda 2030 ambition of leaving no one behind.

The full project team comprises researchers from two African Research Universities Alliance (ARUA) Centres of Excellence hosted by the University of Cape Town (UCT); researchers from the centres' regional nodes at universities in Ghana and Kenya; and collaborators from four universities in the United Kingdom:

- African Centre of Excellence for Inequality Research, hosted by UCT's Southern Africa Labour and Development Research Unit, School of Economics
- ARUA Centre of Excellence in Climate and Development, hosted by UCT's African Climate and Development Institute
- ARUA-CD and ACEIR nodes convened respectively by the Institute for Environment and Sanitation Studies and the Institute of Statistical, Social and Economic Research, University of Ghana
- ARUA-CD and ACEIR nodes convened respectively by the Institute for Climate Change and Adaptation and the School of Economics, University of Nairobi
- Grantham Research Institute on the Environment and Climate Change, London School of Economics and Political Science
- Townsend Centre for International Poverty Research, University of Bristol
- International Inequalities Institute, London School of Economics and Political Science
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The support of ARUA and UK Research and Innovation is gratefully acknowledged.

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Abstract

Household assets serve as coping mechanisms for households during periods of shocks such as those related to climate change. In this study, we explore the buffering capacity of different household assets in smoothing consumption during periods of climate shocks. We combined a three-wave dataset of household socio-economic characteristics spanning about 8 years with a multi-scalar index which captures the duration and intensity of wetness or dryness at a particular location. Using random-effects models, the total value of household assets as well as their disaggregation into six classes of assets were analysed – the value of households' ownership of livestock, agricultural equipment, non-agricultural land, financial assets, business assets and durable goods. The results show that severe flood events have a significant negative effect on households' welfare, but the buffering effect of household assets depends on the duration of flood, type of asset and household location. For instance, some assets which may be described as productive assets such as livestock and agricultural tools tend to be maintained or protected throughout the duration of floods, but the effect of livestock matter for urban households whilst that of agricultural tools matter for rural households. Again, although non-agriculture land tends to be deployed after a much longer duration of floods, it serves as a buffer throughout the length of floods for rural households. These findings contribute to understanding the complex relationships between different assets and climate shocks, which are fundamental to enhancing the design and effectiveness of various asset accumulation interventions to mitigate the welfare effects of protracted crises.

Keywords: Climate shocks; Assets; Welfare; Ghana

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1. Introduction

Economic and human activities such as the burning of fossils and changes in land use over the years have increased the concentration of carbon dioxide, nitrous oxide and methane in the atmosphere, and have led to intense atmospheric heat, drying and climate variability across the globe (Aryal *et al.,* 2022; Iyiola *et al.,* 2022; IPCC, 2007). The concern is not only because they have health implications (Abayomi & Cowan, 2014), but they also pose a threat to livelihoods and most importantly food security (Oduniyi & Tekana 2019). While the impact of climate change can be felt around the globe, its effects are felt disproportionately, with the impact being more pronounced in developing countries (Zhou *et al.* 2022). The impacts are more severe in rural communities where there is high dependence on natural resources compared to urban areas (Morton, 2007). Households in these communities usually have limited capacity to cope with extreme variability in weather conditions, making them very vulnerable. Again, given the devastating impact of poverty, rural households who are usually poor and lack resources are expected to be much affected by climate shocks (Ncube *et al.*, 2015).

Although different strategies ranging from on-farm to off-farm measures have proven to mitigate the adverse effects of climate change (Kom *et al.* 2020), some households are unable to implement them due to the lack of or limited resources available to them (Bryan *et al.*, 2009). Climate shocks such as drought, bush fires and floods destroy farmlands and can lead to a drastic reduction in crop yields and livestock (Ncube *et al.*, 2015; He & Chen, 2022); and the impact of such exogenous shocks on income and consumption can be devastating in the absence of physical assets, financial support and/or social safety nets (Beltrán-Tolosa *et al.*, 2022). Depending on the type of climate shock and location of households, the effects could be different. For example, while drought is expected to impact negatively on household consumption expenditures, the impact of floods could increase or reduce household expenditures. Irrespective of the direction of impact on household consumption expenditures, the availability and access to a wide range of assets helps in buffering the effect during the period of the shock. However, depending on its nature and the type of assets available and accessible to the household, different reactions are to be expected from households in coping with the shock. Projections on weather changes show that the adverse effect of climate change will be frequent, and extreme (Acosta *et al.,* 2021), and coping strategies to buffer these adverse shocks largely depend on available resources or assets at the disposal of households.

Households with limited assets to liquidate are likely to be more vulnerable to climate shocks by not being able to smooth their consumption compared to those with more assets to liquidate (Ncube *et al.,* 2015; Ba and Mughal, 2022). Thus, access to a wide range of assets reduces their level of vulnerability (Ncube *et al.*, 2015; Beltrán-Tolosa *et al.*, 2022). An under-explored aspect of the role of assets is the understanding of how households deploy and make strategic or dynamic decisions for different assets based on different intensities or durations of climate shocks. Generally, five main categories of assets are identified in the literature - natural, physical, financial, human and social capital (Dasgupta and Baschieri, 2010; Ncube *et al.*, 2015; Beltrán-Tolosa *et al.*, 2022). This diverse portfolio of assets may be important for different types of climate shocks, with some used as protective strategies for recovery from an extended shock (Acosta *et al.* 2021). Evidence on such linkages is however limited.

Given this background, the main purpose of this paper is to examine the extent to which climate change shocks, in this case excess precipitation, affect the welfare of households in Ghana, and also investigate the extent to which different assets minimize the effect of climate shocks on household expenditures. A good appreciation of the role of different assets in this context will help inform policymakers in the quest to promote efficacious measures in asset formation for different households. The study contributes to the literature on the roles of different household assets in mitigating the impact of climate change, which is critical to achieving Sustainable Development Goals one, two, three and thirteen - eradicating poverty and reducing hunger; improving good health and well-being; and climate action. The section that follows presents a review of the extant literature. This is followed by the methodology, discussion of results and conclusion.

2. Literature review

According to the United Nations[3], climate change refers to the long-term shifts in temperatures and weather patterns. However, there are several measures used in the literature for measuring the resulting climate shocks. For example, the prolonged absence of rain or drought intensity has been used by some authors (Ba and Mughal, 2022; Dasgupta and Baschieri, 2010; van der Geest and Dietz, 2004) while others use various measures of temperature anomalies (Ncube *et al.*, 2015; Beltrán-Tolosa *et al.,* 2022). Deficiency in rainfall or drought has also been explored in the literature of climate change and adaptation strategies (van der Geest and Dietz, 2004). In many situations, the frequency, duration and intensity of shocks such as drought could have different levels of impact on households (Acosta *et al.,* 2021; Ba & Mughal, 2020).

A study in Ethiopia by He & Chen (2022) reveals that high temperatures above 32 degrees Celsius can be harmful to crop growth. This study used household and plot-level data in the 2011/12, 2013/14 and 2015/16 growing seasons. Findings from the study revealed that each additional average degree increase in harmful temperature above 32°C would lead to a reduction in households' forests by 24.7 percent. Farmers who do not migrate or engage in off-farm employment expand their cropland during very high temperatures. Nonetheless, cropland expansion, in the face of weather shocks was only

[3] https://www.un.org/en/climatechange/what-is-climate-change Accessed:25/11/2022

significant for households with fewer assets. This implies that households with more assets rely on other alternatives while those with fewer resources would expand their cropland.

Possession of assets has been shown to help mitigate the adverse effect of climate change. Financial assets in the form of participation in formal savings schemes and households' access to credit provide a buffer against the negative shocks of climate change (Ba and Mughal, 2022; Ncube *et al.,* 2015). Following an integrated approach known as the five livelihood capitals (natural, social, human, physical, and financial) Beltrán-Tolosa *et al.* (2022) concluded that off-farm income or remittances are sources of adaptive capacity that could support the household to withstand the adverse impact of climate change. Measuring climate shocks as increases in rainfall and temperatures as well as the abrupt changes in temperature, Beltrán-Tolosa *et al* (2022) showed that households with higher rural livelihood diversification in terms of greater agro-ecological management practices and farming diversification are less vulnerable to climate shocks.

Similarly, social assets in the form of inward transfers or remittances from former household members and networks that enable households to receive climate information or help from extension services play a significant role in minimizing household vulnerability (Dasgupta and Baschieri, 2010; Ncube *et al.*, 2015). Some knowledge of climate change helps households to prepare and adapt to the impact of climate change thereby mitigating its adverse impact (Ncube *et al.,* 2015). Information is usually obtained through the social capital of the household, thus their ability to relate and participate in activities. Oduniyi *et al.* (2019) found that in South Africa, the frequency of agricultural extension agent visits and the awareness of such visits were important factors in the implementation of adaptation strategies to ensure the food security of smallholder farmers when faced with climate shocks. According to Dasgupta and Baschieri, (2010) the household's access to the road serves as a proxy by which the household can interact with the outside world and receive information or help. While Mbiba *et al.* (2019) identified households' social assets as their membership in groups, kinship connections, and reciprocity, Beltrán-Tolosa *et al.* (2022) focused on the household's personal relations, participation and benefits derived from an organization, exposure to conflict and migration due to conflict.

Conventionally, livestock serve as a means of storing wealth for rural households (Alary *et al.*, 2014, Acosta *et al.*, 2021; Ba & Mughal, 2020). This confirms studies by Acosta *et al.* (2021) using data from 19 countries from 4 continents, where they find that access to livestock could serve as a buffer against the effect of different types of droughts on household consumption and income. In their study, the standardized precipitation-evapotranspiration index (SPEI) which gives the magnitude and duration of the drought was used as a proxy for drought. According to Acosta *et al.* (2021), the buffering effect of livestock is however dependent on the type of livestock, socioeconomic conditions, as well as the duration of the shock. Regarding the buffering effect of livestock access to a goat is the highest contributor to income, followed by poultry, pigs, sheep and then cattle.

In addition, the study revealed that in the first income quintile the buffering effect of poultry is greater compared to the other species, but in the event of a prolonged shock, households rely on cattle and may seek other coping mechanisms.

Ba & Mughal (2020) compare the impact of two different drought events in 2008 and 2014 on the adaptation strategies employed by rural households and their effect on welfare in Mauritania. A wealth index score of livestock was used as a proxy for household asset ownership. The composition of the index included the number of cattle and camels, sheep and goats and donkeys and horses. While the 2008 drought was localised with 45 percent of rural households losing their livestock during the drought, the 2014 drought affected almost every part of the country. Using a wealth index score as a proxy for household wealth, the study showed that household wealth fell during both periods of drought, suggesting that most farm households liquidated their assets, especially livestock in order to maintain consumption

Mbiba *et al.* (2019) examined the role of natural resources and social capital as buffers against negative shocks to reduce vulnerability in rural livelihoods. Negative shock was modelled as a binary variable (Yes/No) to indicate whether the household has experienced a negative shock in the past 12 months and second, a continuous variable measured by the accumulation of total shocks the household experienced in a year. The study constructed multilevel models based on a five-year panel data from a rural population in South Africa. It found that the negative climate change shocks were statistically significantly associated with the type of natural resources used, the quantities of natural resources used, and the frequency of the natural resources used. Contrary to the expectation, social capital did not significantly reduce natural resource use when the households' experienced shocks.

For a panel of Ethiopian households spanning 15 years, Gao and Mills (2018) examined the impact of weather shocks on consumption and poverty dynamics. Their results indicate a negative association between high temperature and per-adult equivalent consumption, but there is a positive association for rainfall and per-adult equivalent consumption. Formal social net transfers were found to reduce the impact of rainfall shocks on consumption, whilst off-farm employment mitigates the shocks associated with high temperatures. This emphasizes the idea that household response differs by the nature of climate shock.

In a survey of 1800 farm households in Ethiopia and South Africa, Bryan et al. (2009) showed that depending on the context, different asset types could buffer the devastating effects of climate shocks. For example, while access to credit and wealth matter for the decision to vary farming practices due to changes in climate in both Ethiopia and South Africa, other factors such as climate information and extension services were necessary for those in Ethiopia whereas government support and fertile land mattered for the South African sample. Again, ownership of cell phones or cars by households influenced adaptation in South Africa, but this was not the case in Ethiopia, where ownership of radios was important for adaption.

While studies from Ghana are scanty, their findings are not different from those already reviewed in this section. Using the Ghana Living Standards Survey (GLSS) and employing Moser's (1998) asset vulnerability framework to construct an index for vulnerability, Dasgupta and Baschieri (2010) found that being poor as well as having a lower asset index makes one vulnerable to the impact of climate shocks. An interesting finding was that while some households were not classified as poor, they were found to score very low on the asset vulnerability index, making them vulnerable to the impact of climate shocks. This confirms that poverty alone is not a sufficient yardstick to identifying households that may be vulnerable to climate shocks. The assets employed in this framework include human capital and non-labour productive assets such as land, sewing machines, motor vehicles, radios and refrigerators.

Using the north-eastern part of Ghana as a case study and applying a systematic literature review as support, Antwi-Agyei *et al*. (2013) concluded that aside the provision of financial support through participation in micro-credit schemes, social and institutional networks such as providing community and extension services to farming communities will go a long way to empower these communities against climate shocks. Kumasi (2019) also highlight that for farmers in the Upper East Region, communal pooling which involves joint ownership and sharing of household labour plays a major adaption strategy to mitigating adverse effects of climate shocks. The study also found that compared to male farmers, female farmers were less capable of coping with climate shocks due to the greater constraint they face regarding access to climate information, credit facilities, property rights of farmlands and access to irrigation facilities. A more specific study of the economic impact of climate change on the production of cereals was conducted by Nyuor *et al*. (2016) in the Northern Region of Ghana. Using Ricardian regressions, the study found different levels of impact of climate shocks on net revenues of farmers. Although mid-year rains are recorded to boost maize production, early precipitation or rainfall was harmful for maize but beneficial for sorghum. Thus, the timing and shifts in patterns of rainfall in Ghana affect cereal production but the effect varies with the type of cereal. The study did not however consider the role of assets in mitigating the negative effects of climate change.

Not only do assets influence the level of vulnerability of the household towards welfare and livelihoods in the face of a climate shock, but the demographic characteristics of the household also play a critical role in the extent to which the household can withstand a climate shock. For instance, investigating the impact of climate change at the micro-level in South Africa, the results indicates that the higher the age of the household head, the higher the level of vulnerability to the impact of climate shocks (Ncube *et al.,* 2015). While Ncube *et al*. (2015) found female-headed households in South Africa as more likely to be vulnerable to climate shocks, Mbiba *et al*. (2019) found that, gender of the household head in rural South Africa does not influence the use of assets in mitigating climate shocks.

Using data from two South African provinces, Ncube *et al*. (2015) investigated the micro-level impact of climate change and assessed household vulnerability to the impact of climate shocks. They also evaluated alternative adaptation strategies in rural communities by examining household's access to different types of assets - including natural assets (e.g. land and water), physical assets (e.g., livestock and equipment), financial assets (e.g., savings, remittances or pensions) and social assets (e.g., formal and informal social welfare support, access to information). The study found that climate shocks significantly reduced crop yields. Households with relatively fewer asset portfolios were the most vulnerable in this situation and are mostly characterized by elderly people and headed by women. The study also confirmed that households with access to remittances or participated in formal community savings schemes or had access to extension services were less vulnerable. A study by Haile (2021) has also shown that cash transfers mitigate the impact of negative rainfall shocks on households, especially with regard to the welfare of children.

As this review has shown, assets are important in mitigating the negative impact of climate change or shocks, but their impact could differ by the nature of the shock and the asset type (Acosta *et al.,* 2021; He & Chen, 2022; Bryan *et al.,* 2009). However, evidence on estimating the buffering effects for different asset portfolios is generally scanty and non-existent. This study utilises a panel dataset which spans 8 years to investigate such issues for Ghana.

3. Methodology, methods, and data

3.1 Data and Methods

Household-level data are drawn from the Ghana Socioeconomic Panel Survey (GSEPS), a nationally representative panel dataset spanning almost eight (8) years and covering 5009 households. The survey collection exercise involved a two-staged sampling design based on the previous 10 administrative regions of Ghana. The GSEPS collected its first round of data in 2009/2010 from a sample of approximately 18,889 household members, who were returned to for re-interview approximately every four years, with the latest round of data collection in 2017/2018. This dataset allows us the opportunity of incorporating a dynamic perspective into the analysis of welfare. The survey also provides information on consumption expenditures incurred on both food and non-food items. To facilitate comparisons across time, all monetary figures are deflated to 2014 prices using the Ghana Statistical Service consumer price index for 2014.

Climate data on long-term dryness and wetness conditions with 0.5 degrees of spatial resolution and a monthly time resolution is drawn from the Global SPEI database. The data is based on monthly rainfall and potential evapotranspiration from the Climate Research Unit of the University of East Anglia. The dataset currently spans between January 1901 and December 2020, but we rely on those corresponding to the years of the household surveys.

3.2 Dependent variable

We used the real consumption expenditure per adult equivalent as the measure of household welfare. The use of consumption as a measure of welfare provides some advantages. First, consumption expenditures are less influenced by transitory shocks and as a result are a better approximation of permanent household income. Again, wealth effects which are reflected in the purchase of some goods such as luxuries are better captured through expenditures than income (Aggarwal, 2021). Moreover, consumption smoothing is also possible through other sources of income such as those from government transfers, which may not be captured by income. Whilst some measurement error is expected in the reported expenditures, it should not affect the regression analysis since the error is unlikely to be correlated with the climate change shocks, thus ensuring consistency of the regression estimates (Pischke, 2007).

3.3 Independent Variables

3.3.1 Climate shocks

According to the 2020 ND-GAIN Index[4], Ghana ranks 109 out of 181 countries considered as vulnerable to climate change impacts and other global challenges as well as the preparedness of resilience. There is a high risk of exposure to multiple weather-related anomalies such as floods and droughts as well as risks related to coastal resources such as storm surges, wildfires and erosion.

Flooding is one of the most threatening climate events in Ghana with adverse social, economic, and environmental impacts. There have been about seven major flood events between 1991 and 2011. In November 2010 for example, Ghana recorded an unprecedented flood which displaced over 700,000 people and affected about 55 communities. The flood also submerged over 23,588 acres of farmlands and destroyed over 3234 houses. A report on the 2010 floods released by the National Disaster Management Organisation (NADMO) estimated the total cost of the flood to be US$116,340.22. Another flood event in 2007 caused damage to infrastructure and livelihoods in excess of $130 million affecting over 256000 individuals in the northern

[4] University of Notre Dame (2020). Notre Dame Global Adaptation Initiative. URL: https://gain.nd.edu/our-work/country-index/

part of Ghana with about 1000,000 needing assistance in varying forms to cope with the adverse effects. Moreover, in June 2015, a flood event resulted in the death of over 150 people (Asumadu-Sarkodie et al., 2015).

The situation is widespread and pervasive (Asumadu-Sarkodie et al., 2015b) mainly due to unstable rainfall patterns which has been cited as the major cause of flood (Amoako and Inkoom, 2018; Asumadu-Sarkodie et al., 2015). For instance, the average monthly precipitation for Accra over the past two decades has increased - from an average of 160mm to 200mm between (1991-2010) and (2011-2020). Aside rendering people homeless and negatively affecting livelihoods and properties, flood poses as a health risk to the exposed population through exposure to the contracting of diseases such as malaria, cholera, and hepatitis (Few, 2013; Alderman et al., 2012). A major factor for the recurrence of flood especially in urban areas is poor structural and physical planning (Owusu-Ansah, 2016; Tasantab, 2019) which culminate into poor drainage and waste management systems that worsen the effects of flooding. Research shows that climate change increases the probability of severe rainfall, its duration and frequency (Mirhosseini et al., 2013) creating the risk of flooding and its associated adverse effects on household welfare, health and the environment (Hettiarachchi et al., 2018; Alderman et al., 2012; Kikwasi and Mbuya, 2019).

Given this background, our measure of climate shock for this study is severe wetness or flooding. We combined the household-level information from the GSEP survey with several variables on wetness or dryness depending on the intensity. This is made possible by matching the geo-referenced locations of households from the GSEPS dataset with those of the dryness or wetness data set which are captured at high-resolution gridded scales.

We use the Standardized Precipitation-Evapotranspiration Index (SPEI)[5] from the Global SPEI database (Bequeria *et al*., 2017) as the main variable for capturing severe wetness. Although the SPEI is generally regarded as a drought index, its multi-scalar nature allows it to be used in measuring the severity of dryness or wetness based on its duration and intensity. Unlike the Standardized Precipitation Index (SPI) which is only based on precipitation and is a common alternative in the climatologic literature (see Livada & Assimakopoulos 2007; Zuo *et al*., 2022; Gader *et al.,* 2022) the SPEI accounts for warming-induced drought stress. When considering future weather conditions, the SPI does not consider the role of temperature increases. Further, although other drought measures such as the Palmer Drought Severity Index (PDSI) and the self-calibrated PDSI incorporate temperature data in their formulation, they are not multi-scalar measures which is necessary for drought assessment when considering different hydrological systems and identifying various drought types and intensity. The SPEI allows for considering different flood types through its monthly resolution, calculated between 1

[5] Detailed description of the methodology for constructing the SPEI is available at: http://spei.csic.es/. Open Database.

and 48 months. It associates a high frequency of dry and wet periods of short duration with time scales below 12 months. In contrast, dry and wet events of longer duration and low frequency are associated with longer time scales. Thus, different types of SPEI provide evidence of different tendencies of dryness and wetness. The SPEI is a standardized variable with mean zero and variance of one and having both negative and positive values. Generally, negative SPEI values indicate higher than average temperatures and low precipitation, whereas positive values on the other hand indicate higher than average precipitation and low temperatures (McKee et al., 1993; Tefera et al., 2019). Based on the SPEI, we constructed a proxy for severe wetness or flooding events which takes a value of 1 if the SPEI is greater than 0.5 and zero otherwise. With a spatial resolution of 0.5x0.5, the localized value of the SPEI is assigned to each household in the survey using the precise geological location of the households. To avoid short and possibly insignificant climatic anomalies in the SPEI index, we follow the work by Acosta et al. (2021) and select SPEIs of 12, 24 and 48 months for analysis.

3.3.2 Household Ownership and Value of Assets

To smoothen consumption after a shock, households accrue assets during periods of good fortune and use them to maintain consumption (Deaton, 1991; Rosenzweig & Wolpin, 1993). The literature distinguishes between various types of assets that households may adopt to smooth consumption, ranging from productive assets such as livestock and land and non-productive assets such as cash savings (DeLoach & Smith-Lin, 2018; Isoto *et al.*, 2017). Generally, households with more assets are expected to be more capable and resilient to climate shocks. Meanwhile, different types of assets may be important for different types of shocks at various levels of severity (Paul, 1998; Acosta *et al*, 2021).

We used six classes of assets to examine the extent to which they serve as buffers in smoothing consumption for various climate shocks. The assets include the value of households' ownership of livestock (Acosta *et al.,* 2021), agricultural equipment, non-agricultural land, financial assets (Antwi-Agyei *et al*., 2012), business assets (Heltberg *et al.,* 2015) and consumer durables (Nsubuga et al., 2021). The GSEP survey provides information on the ownership and the value of these assets belonging to household members at the time of the survey. To control for the influence of social networks, we include a dummy for household in-transfers of goods and cash which come from individuals who are not members of the household. Table A1 presents the asset portfolio and the various items in each portfolio (see Appendix).

Table 1: Asset distribution by class and across survey waves (Average nominal values for owners of assets)

	Pooled sample	Wave 1 - 2009/2010	Wave 2 - 2013/2014	Wave 3 - 2017/2018
Total Asset Value (Gh₵)	**7,268**	**2,472**	**8,227**	**12,751**
Number of obs	*12,707*	*4,999*	*3,970*	*3,738*

Land (Gh₵)	**7,935**	**2,147**	**9,355**	**13,543**
Number of obs	*2,730*	*950*	*1,089*	*691*
Durable Goods (Gh₵)	**2,933**	**1,220**	**2,747**	**5,418**
Number of obs	*12,694*	*4,986*	*3,970*	*3,738*
Livestock (Gh₵)	**1,842**	**706**	**1,729**	**3,334**
Number of obs	*5,709*	*2,142*	*1,856*	*1,711*
Business Assets (Gh₵)	**1,543**	**489**	**1,293**	**3,301**
Number of obs	*4,716*	*1,803*	*1,608*	*1,305*
Financial Assets (Gh₵)	**1,286**	**363**	**1,541**	**2,239**
Number of obs	*7,535*	*2,943*	*2,345*	*2,247*
Agric. Tools (Gh₵)	**192**	**87**	**229**	**328**
Number of obs	*11,857*	*4,999*	*3,970*	*2,888*

Source: Authors' computations using three waves of the GSEPS.

As illustrated in Table 1, the distribution of assets indicates a consistent increase in the nominal value of total assets across the survey waves. For households that own various assets, land has the highest average value followed by durable goods, livestock, business assets and financial assets. This trend is generally consistent across the three waves of the survey, except for the second wave where the average value of households' financial assets exceeds that of their business assets.

Across the various ecological zones, the households in the coastal areas appear to control most of the assets in terms of value (see Table 2). Table 2 shows that the average values of total assets in the possession of households in the forest and Savannah zones are very close, although that of the Savannah zone is slightly higher. However, it is important to note that the marginally higher total value of assets for the Savannah zone can be attributed to the high value of livestock in that zone relative to the Forest zone. The Savannah zone ranks least in almost all the asset classes aside livestock and agricultural tools where their values are the highest when compared to the Coastal and Forest zones (see Table 2). As expected, aside livestock and agricultural tools, households located in urban communities have higher average asset values. This is reasonable since livestock rearing and farming in general are predominantly undertaken by rural households (see Table 2).

Table 2: Asset distribution across ecological zones and household location (Average nominal values for asset owners)

	Ecological zones			**Household location**	
	Coastal	**Forest**	**Savannah**	**Urban**	**Rural**
Total Asset Value	**6,668**	**4,621**	**4,969**	**9,282**	**5,192**
Number of obs	*3,222*	*5,769*	*3,716*	*5,026*	*7,681*
Land	**7,792**	**6,041**	**4,021**	**10,276**	**5,797**
Number of obs	*667*	*1,404*	*659*	*1,057*	*1,673*

Durable Goods	**3,051**	**1,726**	**1,683**	**4,380**	**1,440**
Number of obs	*3,217*	*5,763*	*3,714*	*5,022*	*7,672*
Livestock	**963**	**565**	**2,267**	**1,526**	**1,960**
Number of obs	*753*	*2,342*	*2,614*	*1,025*	*4,684*
Business Assets	**1,540**	**812**	**739**	**2,144**	**596**
Number of obs	*1,382*	*2,276*	*1,058*	*2,371*	*2,345*
Financial Assets	**1,052**	**906**	**807**	**1,411**	**1,124**
Number of obs	*1,968*	*3,902*	*1,665*	*3,445*	*4,090*
Agric. Tools	**196**	**81**	**234**	**190**	**194**
Number of obs	*2,815*	*5,414*	*3,628*	*4,368*	*7,489*

Source: Authors' computations using pooled data from the three waves of the GSEPS.

To capture the influence of other correlates, some household-level characteristics are included in the analysis. These include household head characteristics such as gender, age, education level and employment type or status. Also included are household composition variables relating to the number of elderly and children within the household, as well as the dependency ratios for households. Dependency ratios are computed as the ratio of household members below 15 and over 65 years of age to total household membership. The number of household members who are employed is included to control for resource pooling within the household. We finally include spatial controls using district level dummies.

3.3.3 Empirical strategy

We make use of the panel of three waves from the GSEPS and estimate different versions of the random effects model based on the SPEI muti-scalar variable for the severity and duration of flooding. We choose the random effects model over fixed effects model mainly because our measure of climate shock is time invariant, thus estimating fixed effects will cause it to drop off. We control for municipal or district fixed effects as a result of climate shocks which usually affect a wide area like a whole village or district. Thus, although we measure the extent of wetness or flooding at the household level, it is necessary to include district or municipal dummies to soak up any plausible fixed effects. To evaluate the effectiveness of household assets in mitigating the impacts of climate shocks on per-adult equivalent consumption, the following model is estimated:

$$C_{it} = \beta_1 + \beta_2 X_{it} + \beta_3 S_{it} + \beta_4 A_{it} + \beta_5 (S_{it} \otimes A_{it}) + \delta_d + \varepsilon_{it} \quad (1)$$

where,

C_{it} is the log of per adult equivalent consumption of household *i* at time *t*,. X_{it} is a vector of household head characteristics which includes female dummy, age, education level, and employment type or status. S_{it} is a vector of climate shock variables, which are the SPEI indexes for the severity of drought. We use three different SPEI indexes: 12, 24, and 48 months and replicate the regressions for each. A_{it} is the log of total value of asset portfolios available to households. This is made up of the value of six classes of assets – livestock; agricultural tools; non-agricultural land; household durable goods; financial assets; and business assets (see Table A1 in the appendix for a detailed list of the various assets). The product of asset values and the SPEI index is included to measure the buffering effect of assets on climate shocks. δ_d is a vector of district dummies; and ε_{it} is the stochastic error term. δ_d capture unobserved district-specific effects across households. It is reasonable to assume that different types of assets may be important for different households depending on the spatial characteristics within which the households reside. Thus, aggregated results may not reflect such nuances as well as plausible spatial effects. To control for such heterogeneity, we estimated different versions of the regression model to assess the effects for the full, rural and urban samples; and this is done for the total value of assets as well as estimations that consider the six classes of assets.

Acquisition of assets can be embedded in interactive relationships This raises the concern for endogeneity due to omitted variable bias[6]. Although the analysis controls for several covariates to reduce the endogeneity effects of omitted variable bias, the concern for endogeneity still stands valid. One major source of the problem is the fact that households would usually invest in mitigation strategies against climate shocks such as floods and as a result deplete their assets. A solution to such endogeneity problem would have been to find an instrument for assets which is not related to climate change or shocks (but should be a shock in itself) to account for the variation in assets due to the mitigation actions of households. Unfortunately, our data lacks such an instrumental variable for assets.

It is difficult to predict the direction of the effect of flooding on household expenditures a prior since severe flooding can increase or decrease consumption expenditures of households. However, for household assets to have a favourable impact on household consumption expenditures, their effect must be positive and significant. Finally, household assets are considered to have a buffering effect on the adverse impact of climate shocks on household consumption expenditures when the interaction term is significant and positive.

4. Results and discussions

Table 3 present the results of different versions of the random effects model as shown in equation (3). The estimations illustrate the effects of climate shocks and the buffering role of assets against such shocks. To capture plausible spatial heterogeneity among

[6] Endogeneity due to omitted variable arises in a model if the dependent variable is correlated with any of the independent variables because of omission of some important variables, which are captured in the error term (Wooldridge, 2010).

households, we also estimate the results for the rural and urban sub-samples. Generally, the results show significant and to some extent complex relationships between the various asset portfolios, flood duration, spatial location, and household welfare (see Table 3).

Overall and as shown by the full sample estimation, severe flooding has a negative and significant effect on the consumption expenditures of households; but this is true for rural households and not those in the urban communities. Proxied by the SPEI variable, our results suggest that the effect of floods on household consumption expenditures is negative, but the extent of the effect depends on the duration of the shock (see Table 3). Considering the full sample, one can observe that severe flooding occurring in a short-term (SPEI 12) leads to about 75 percentage points decrease in the real per adult equivalent (p.a.e) consumption expenditures of Ghanaian households. As the duration of flooding conditions increases to 24 months (SPEI 24), the effect significantly decreases to about 21 percentage points reduction in real p.a.e consumption expenditures of households. A further extension of the duration of flooding to 48 months (SPEI 48), although negatively impacting on consumption, only reduces real pae consumption by about 17 percentage points, which is a lesser impact compared to the duration of 12 months and 24 months. As reported by previous studies (Acosta *et al.*, 2021; Kochar, 1999; Gray and Mueller, 2012), the relatively milder impact of an extended period of climatic stress suggests that households adopt and implement other long term coping strategies such as shifting from farm to non-farm employment and labour migration.

Table 3: Effect of Household Total asset portfolio as a buffering mechanism against climate shocks

Real Consumption Expenditures (p.a.e)	Full sample			Urban sample			Rural sample		
	SPEI 12	SPEI 24	SPEI 48	SPEI 12	SPEI 24	SPEI 48	SPEI 12	SPEI 24	SPEI 48
SPEI	-0.7519***	-0.2084***	-0.1711***	0.4155***	0.2477**	0.0989	-0.1261	-0.2882***	-0.4675***
	(0.1058)	(0.0727)	(0.0615)	(0.1264)	(0.1002)	(0.1054)	(0.1029)	(0.0871)	(0.0858)
Household Total Asset (log)	0.0346***	0.0296***	0.0312***	-0.0141*	-0.0160*	-0.0174	0.0853***	0.0653***	0.0428***
	(0.0042)	(0.0045)	(0.0049)	(0.0079)	(0.0090)	(0.0115)	(0.0072)	(0.0081)	(0.0101)
SPEI*Total Asset (interaction)	-0.0099	0.0123	0.0484***	-0.0916***	-0.0374***	0.0098	-0.0586***	-0.0085	0.0363***
	(0.0130)	(0.0099)	(0.0084)	(0.0167)	(0.0131)	(0.0135)	(0.0151)	(0.0133)	(0.0124)
In-transfers to HH (dummy)	-0.0649	-0.0554	-0.0668	-0.0014	-0.0134	-0.0310	-0.2994*	-0.2977*	-0.3058
	(0.0547)	(0.0570)	(0.0562)	(0.0815)	(0.0866)	(0.0888)	(0.1770)	(0.1786)	(0.1894)
Dependency ratio	0.0069	0.0013	-0.0013	-0.0037	0.0033	0.0064	-0.0081	-0.0113	-0.0216
	(0.0246)	(0.0253)	(0.0249)	(0.0513)	(0.0522)	(0.0521)	(0.0374)	(0.0383)	(0.0389)
Number of elderly	-0.0350**	-0.0268*	-0.0330**	-0.0075	-0.0125	-0.0203	-0.0518**	-0.0596**	-0.0581**
	(0.0149)	(0.0153)	(0.0153)	(0.0306)	(0.0312)	(0.0314)	(0.0250)	(0.0255)	(0.0257)
Number of children	0.0200*	0.0189*	0.0186	0.0036	0.0020	0.0031	0.0305*	0.0313*	0.0410**
	(0.0109)	(0.0112)	(0.0114)	(0.0198)	(0.0201)	(0.0201)	(0.0185)	(0.0188)	(0.0190)
Household size	-0.0546***	-0.0535***	-0.0558***	-0.0020	-0.0006	-0.0021	-0.0656***	-0.0708***	-0.0801***
	(0.0087)	(0.0089)	(0.0091)	(0.0151)	(0.0153)	(0.0154)	(0.0149)	(0.0151)	(0.0153)
HoH age (number of years)	-0.0104***	-0.0118***	-0.0100***	-0.0256***	-0.0251***	-0.0233***	-0.0085**	-0.0089**	-0.0104***
	(0.0021)	(0.0021)	(0.0021)	(0.0043)	(0.0043)	(0.0043)	(0.0038)	(0.0038)	(0.0038)
HoH age squared (x0.01)	0.0093***	0.0102***	0.0094***	0.0184***	0.0184***	0.0176***	0.0094**	0.0101***	0.0115***
	(0.0020)	(0.0021)	(0.0021)	(0.0043)	(0.0044)	(0.0044)	(0.0037)	(0.0038)	(0.0037)
HoH female (base is male)	0.0477***	0.0515***	0.0619***	-0.0162	-0.0056	0.0035	-0.0042	0.0044	0.0222
	(0.0109)	(0.0109)	(0.0108)	(0.0253)	(0.0253)	(0.0259)	(0.0243)	(0.0247)	(0.0246)
Employment status: (base is unemployed)									
Paid employee	0.1133***	0.1247***	0.0822**	0.2834***	0.2987***	0.2612***	0.0235	0.0752	0.1205**
	(0.0323)	(0.0335)	(0.0331)	(0.0529)	(0.0542)	(0.0540)	(0.0528)	(0.0538)	(0.0547)
Household farm	0.0825***	0.0796**	0.0559*	0.3682***	0.3757***	0.3650***	0.0579	0.0980**	0.1393***
	(0.0305)	(0.0318)	(0.0319)	(0.0593)	(0.0608)	(0.0608)	(0.0465)	(0.0473)	(0.0485)
Non-farm farm	0.0669**	0.0659**	0.0474	0.2087***	0.2226***	0.2027***	0.0472	0.0884*	0.1220**
	(0.0295)	(0.0306)	(0.0305)	(0.0514)	(0.0529)	(0.0527)	(0.0485)	(0.0494)	(0.0508)
Unpaid housework	0.1174***	0.1259***	0.1141***	0.2322***	0.2288***	0.2072***	0.2092***	0.2304***	0.2558***

	(0.0349)	(0.0358)	(0.0353)	(0.0606)	(0.0620)	(0.0620)	(0.0544)	(0.0556)	(0.0566)
Not in labour market	0.0333	0.0213	-0.0041	0.2346***	0.2349***	0.2097***	-0.0099	0.0004	0.0050
	(0.0314)	(0.0327)	(0.0327)	(0.0551)	(0.0563)	(0.0562)	(0.0443)	(0.0450)	(0.0461)
missing or other	-0.1347***	-0.1682***	-0.1161***	-0.2248***	-0.2231***	-0.2104***	-0.0777	-0.0589	-0.0263
	(0.0350)	(0.0360)	(0.0352)	(0.0603)	(0.0624)	(0.0631)	(0.0620)	(0.0643)	(0.0654)
No. of members employed	-0.0109	-0.0174	-0.0181	-0.0477**	-0.0539***	-0.0591***	0.0173	0.0186	0.0189
	(0.0099)	(0.0107)	(0.0111)	(0.0200)	(0.0203)	(0.0204)	(0.0142)	(0.0147)	(0.0153)
Educational qualification (base is no education)									
Basic or Middle School Certificate	0.0263*	0.0276**	0.0179	0.0276	0.0249	0.0154	-0.0139	-0.0054	-0.0076
	(0.0134)	(0.0135)	(0.0133)	(0.0312)	(0.0316)	(0.0320)	(0.0255)	(0.0260)	(0.0261)
Vocational/Technical	0.0594**	0.1235***	0.0937***	0.1175**	0.1104**	0.0728	0.0238	0.0567	0.0297
	(0.0241)	(0.0309)	(0.0293)	(0.0465)	(0.0472)	(0.0471)	(0.0551)	(0.0573)	(0.0564)
Secondary /O&A level	0.1070**	0.0527**	0.0460*	0.0606	0.0528	0.0300	0.0395	0.0138	-0.0056
	(0.0465)	(0.0248)	(0.0243)	(0.0421)	(0.0425)	(0.0430)	(0.0577)	(0.0617)	(0.0626)
Teacher /HND	0.0208	0.1213**	0.1044**	0.1639**	0.1606**	0.1418*	0.1571*	0.1935**	0.1926**
	(0.0449)	(0.0487)	(0.0484)	(0.0711)	(0.0722)	(0.0724)	(0.0907)	(0.0896)	(0.0887)
Degree (Bachelors/masters)	-0.0388**	0.0051	0.0113	0.0793	0.0671	0.0475	-0.1040	-0.0636	-0.0543
	(0.0167)	(0.0449)	(0.0446)	(0.0688)	(0.0692)	(0.0692)	(0.1002)	(0.1020)	(0.1020)
others & missing	0.0594**	-0.0389**	-0.0494***	0.0337	0.0272	0.0189	0.0022	-0.0118	-0.0458*
	(0.0241)	(0.0169)	(0.0171)	(0.0412)	(0.0412)	(0.0419)	(0.0273)	(0.0276)	(0.0272)
Constant	4.7479***	4.4270***	4.2604***	5.9935***	5.9502***	5.8453***	5.1451***	5.2631***	5.4749***
	(0.1182)	(0.1142)	(0.1122)	(0.1439)	(0.1512)	(0.1678)	(0.2044)	(0.2065)	(0.2209)
District Dummies	YES	YES	YES	NO	NO	NO	NO	NO	NO
N	9,911	9,911	9,911	4,554	4,554	4,554	6,281	6,281	6,281
Chi2	23,993.02	22,896.45	24,494.00	468.30	317.60	342.17	1,147.45	748.29	520.20

* $p<0.1$; ** $p<0.05$; *** $p<0.01$.

The results for the urban-rural subpopulation signals important heterogeneity or spatial effects of flooding. The trend of results on excessive precipitation for the rural sub-sample is consistent with the evidence for the full sample but the impacts are much greater for longer duration of flooding condition. From a 29-percentage points reduction in the consumption expenditures of rural households due to a 24-month flooding conditions duration, the impact increases to 47 percentage points reduction when the flooding conditions duration extends to 48 months. A surprising but yet expected finding is the positive and significant effect of severe flooding on household overall consumption expenditures in urban areas within the short- to medium duration of flooding conditions (i.e., SPEI 12 and SPEI 24). Our finding demonstrate that urban flood events increases the overall consumption expenditures of households by 42 percentage points in the short-term (i.e. flood duration of 12 month) but the impact reduces to about 25 percentage points when the duration extends to 24months. This finding is consistent with many other studies that find urban floods to have placed enormous costs on individual households in the aftermath of flood which may be classified within any of the following strategies - reactive, preventive or recovery strategies (Danso and Addo, 2017). For instance, (Barimah et al., 2014) showed that urban households in the Upper East Region of Ghana spent between GHC 100 to GHC 500 (i.e., between $45 and $220) as emergency expenses for repair and renovation of their homes after flood. Other studies also demonstrate that flood victims potentially increase expenditures on health due to increase in transmission of communicable diseases and mental health issues (Dziwornu and Kugbey, 2015; Songsore, 2017; Abu and Codjoe, 2018). This finding must however be interpreted with caution as not all categories of consumption may have increased. Focusing on only food consumption expenditures, we find our measure of severe flooding events to have significant negative effect across both rural and urban communities (see Table A2 in appendix). This suggest that while the effect on food consumption is significantly negative, flooding events tend to enormously increase the non-food expenditures of urban households compared to rural such that the net effect is positive for urban households but negative for the rural.

The contribution of total assets to consumption is positive and significant, increasing overall consumption by about 3 percentage points for a percentage increase in total asset value.

The climate-asset interaction variable which indicates the capacity of total assets in smoothing consumption shocks tends to vary by the flood length. The buffering effect of the total value of household assets is insignificant in buffering the negative effects of floods in the short- to medium-term duration of floods but becomes positive under a long-term flood duration (48-months) with a buffering effect of about 5 percentage points. This result is nearly consistent with rural households where the buffering capacity of total assets is negative for a 12-month drought, negative again for a 24 month (yet insignificant) and again positive for a 48-month drought duration. Meanwhile, urban households tend to maintain their asset portfolios during the short- and medium-term flood durations but the long-term effect is positive (a buffering signal although insignificant).

However, households may respond differently in their use of different asset types in mitigating the negative effects of shocks. Households may tend to utilise more liquid assets or those that serve as store-of-value (e.g., savings) first, while they hold on to productive or investment assets (e.g., land) for a longer duration (Acosta et al., 2021; Leroy et al., 2018; Fafchamps et al., 1998) To have a sense of such nuances, we expand the analysis by running similar estimations where the six classes of asset portfolios are included (see Table 4).

The general effects of climate shock and assets on consumption expenditures were similar to those of the main evidence already discussed. The effect of assets on consumption expenditures tends to differ by the type of asset, the duration of flooding conditions, and to some extent the location of the household. Also, the interaction effects which reflects the buffering capacity of the various assets suggest that the capacity to mediate the adverse shock of floods differs by asset type and the length of flood. To properly capture the complexity of the role of assets, we discuss the results of their independent effects together with their interaction effects with the flood variable.

The results for the full sample show that aside household durable goods, all other assets contribute positively to household consumption irrespective of the duration of flooding conditions. These effects however differ slightly across rural and urban households. For instance, for rural households, agricultural tools are positive and significant, but this is not the case for urban households where agricultural tools is significantly negative. Also, household durable goods seem to be important in contributing to consumption expenditures for rural households compared to urban households.

Table 4: Effect of various asset portfolios as buffering mechanisms against climate shocks

Real Consumption Exp (p.a.e)	Full sample			Urban sample			Rural sample		
	SPEI 12	SPEI 24	SPEI 48	SPEI 12	SPEI 24	SPEI 48	SPEI 12	SPEI 24	SPEI 48
SPEI	-0.8599***	-0.2256***	-0.2171***	0.5508***	0.1402	-0.2786***	-0.0542	-0.2631***	-0.5375***
	(0.1051)	(0.0678)	(0.0558)	(0.1326)	(0.1001)	(0.1022)	(0.1006)	(0.0863)	(0.0798)
Livestock	0.0038	0.0073***	0.0112***	0.0091	0.0124**	0.0187***	0.0020	0.0026	0.0040
	(0.0023)	(0.0024)	(0.0027)	(0.0056)	(0.0061)	(0.0072)	(0.0039)	(0.0043)	(0.0053)
Agric tools	0.0027	0.0191***	0.0434***	-0.0254***	-0.0208***	0.0177*	0.0381***	0.0376***	0.0421***
	(0.0039)	(0.0042)	(0.0044)	(0.0062)	(0.0075)	(0.0092)	(0.0079)	(0.0088)	(0.0105)
non-agric. land	0.0129***	0.0138***	0.0083***	0.0133***	0.0158***	0.0126***	0.0027	0.0008	0.0017
	(0.0018)	(0.0019)	(0.0019)	(0.0033)	(0.0040)	(0.0047)	(0.0031)	(0.0034)	(0.0042)
Durable goods	0.0073	-0.0097*	-0.0211***	-0.0514***	-0.0667***	-0.1086***	0.0461***	0.0212**	-0.0181
	(0.0048)	(0.0052)	(0.0056)	(0.0090)	(0.0105)	(0.0133)	(0.0083)	(0.0092)	(0.0116)
Financial Asset	0.0088***	0.0055**	0.0049**	0.0156***	0.0152***	0.0160***	0.0238***	0.0211***	0.0205***
	(0.0022)	(0.0022)	(0.0023)	(0.0037)	(0.0043)	(0.0051)	(0.0039)	(0.0042)	(0.0051)
Business Asset	0.0138***	0.0183***	0.0115***	0.0166***	0.0205***	0.0187***	0.0027	0.0043	0.0036
	(0.0025)	(0.0027)	(0.0028)	(0.0040)	(0.0048)	(0.0059)	(0.0053)	(0.0058)	(0.0072)
SPEI*Livestock	-0.0065	-0.0369***	-0.0296***	-0.0273**	-0.0373***	-0.0329***	0.0109	-0.0095	-0.0181***
	(0.0072)	(0.0066)	(0.0054)	(0.0123)	(0.0107)	(0.0098)	(0.0085)	(0.0072)	(0.0067)
SPEI*Agric tools	0.0015	-0.0894***	-0.0938***	0.0305**	0.0027	-0.0665***	-0.0695***	-0.0649***	-0.0497***
	(0.0125)	(0.0107)	(0.0081)	(0.0143)	(0.0118)	(0.0119)	(0.0183)	(0.0156)	(0.0132)
SPEI* non-agric. land	-0.0112	-0.0018	0.0155***	0.0116	-0.0046	0.0023	0.0195**	0.0250***	0.0153***
	(0.0073)	(0.0056)	(0.0041)	(0.0082)	(0.0065)	(0.0063)	(0.0090)	(0.0073)	(0.0057)
SPEI*Durable goods	0.0099	0.0563***	0.0961***	-0.1246***	-0.0178	0.0883***	-0.0456**	0.0237	0.0852***
	(0.0157)	(0.0111)	(0.0090)	(0.0208)	(0.0156)	(0.0154)	(0.0203)	(0.0169)	(0.0149)
SPEI*Financial Asset	-0.0033	0.0109*	0.0105**	-0.0031	-0.0029	-0.0030	-0.0213**	-0.0086	0.0064
	(0.0077)	(0.0062)	(0.0050)	(0.0094)	(0.0074)	(0.0071)	(0.0090)	(0.0078)	(0.0069)
SPEI*Business Asset	0.0299**	0.0040	0.0134**	-0.0173*	-0.0122	-0.0056	0.0154	0.0249**	0.0202**
	(0.0132)	(0.0072)	(0.0054)	(0.0100)	(0.0078)	(0.0078)	(0.0146)	(0.0111)	(0.0090)
Constant	4.8615***	4.6136***	4.4512***	6.1142***	6.1363***	6.2347***	5.3156***	5.4362***	5.6438***
	(0.1177)	(0.1169)	(0.1135)	(0.1419)	(0.1484)	(0.1603)	(0.1993)	(0.2000)	(0.2129)
N	9,911	9,911	9,911	4,554	4,554	4,554	6,281	6,281	6,281
Chi2	24,376.55	22,477.93	24,520.24	675.55	477.55	604.98	1,204.54	896.49	795.65

All estimations include the following covariates: household inward-transfers dummy; household dependency ratio; number of elderly members; number children; household size; gender of the household head; age of household; employment status of the household head; number of members employed; education qualification of the household head; district fixed effects and predicted residuals of the various assets from the first-stage regressions.

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

The overall buffering effect of durable goods is positive but its effect for urban and rural households is dynamic, alternating from negative to positive depending on the duration of the flooding conditions. The urban and rural analysis suggest that durable assets are maintained in the short term and subsequently sold as the flood prolongs.

Non-agricultural land is only deployed as a buffering mechanism during the long-term duration of floods (see full sample of Table 4). A plausible reason for this may be due to its high intrinsic value and the fact that it is not easily liquidated. Thus, during the early period of a flood, households might depend more on easy to liquidate assets such as financial assets (i.e., savings) and durable goods (see full sample of Table 4), holding on to their productive assets such as livestock and agricultural tools. However, our disaggregated analysis shows that for rural households, non-agricultural land serves a coping mechanism throughout the length of the flooding conditions.

In contrast, the case for livestock and agricultural tools suggest that they are protected or maintained for the medium- to long-term duration of flooding conditions (see Table 4- full sample); however, the maintenance of these assets differs across rural and urban households. Whileslivestock tend to matter for urban households in terms of maintaining their stock throughout irrespective of the length of floods, rural households are more concerned about agricultural tools. As explained by previous studies (Fafchamps et al, 1998), market forces may contribute to significantly increasing returns on livestock production after a climate shock – a reason for households to keep their livestock in anticipation to benefit from the expected benefits. These results make both intuitive and empirical sense as, households face trade-offs between using different asset types to smooth the effects of shocks, or protecting them for future income generation (Corbett, 1988).

5. Conclusions and future research

This study analysed the impact of climate shocks on household welfare in Ghana and analysed the buffering capacity of assets in buffering the adverse effects during climate shocks. Our study shows that the mitigating role of household assets tends to depend on the length of the shock, the type of asset and households' location. We combined information from three waves of a household socioeconomic data set spanning approximately 8 years with a multi-scalar climate shock index which captures the duration and intensity of water-level balance. Our analysis considered the effect of the total value of household assets, as well as the complexities at play when the six classes of assets are analysed – the value of households' ownership of livestock, agricultural equipment, non-agricultural land, financial assets, business assets and durable goods.

By using random-effects models, we are able to include spatial dummies relating to the districts where households are located to reflect the possible homogeneity of weather conditions among households. Again, the analysis was done for the full sample and the rural-urban sub-population in order to capture heterogeneity among socioeconomic groups and ensure robustness against outliers and distributional assumptions. Several covariates of socio-economic factors were included to reduce issues of omitted variable bias. The effects of our variables were ascertained on household welfare, as proxied by the log of per adult equivalent consumption expenditures.

The effect of severe flooding on overall household consumption expenditures is negative with those in rural communities bearing the impact. For urban households, the effect of severe flooding on overall household consumption expenditures is significantly positive, but running the analysis for food consumption shows a negative effect. This suggest that flooding events tend to enormously increase the non-food expenditures of urban households such that the net effect is positive. The extent of the effect of floods on household consumption expenditures tends to depend on the length of the flooding conditions and household location. For the full sample, the effect tends to reduce as the length of flooding conditions increases, but this is not the case for the rural sample – where the effect increases with the length of flood. Further, the capacity of total value of household assets to buffer this effect is positive but only in the long-term (i.e., 48-month duration). While urban households maintain or protect their assets during flood events, the buffering effect of total assets tends to be dynamic – alternating from a negative effect in the short-term (12 months) to positive in the long-term (48-months).

A further analysis on the effect of the various classes of assets revealed interesting complexities in the way assets are utilised as buffering mechanisms. Some assets which may be described as not relatively liquid or not easy to liquidate such as non-agricultural land and durable goods tend to be protected at the onset of a floods until a much longer duration before they are deployed as coping mechanisms; but the sub-sample results show that rural households use non-agricultural land as a buffer throughout the duration of flooding conditions. On the other hand, assets that seem to be much easier to liquidate such as business assets serve as buffering mechanisms throughout the period of floods (see Table 4 -full sample results). In addition, assets that could be referred to productive assets such as livestock and agricultural tools are generally maintained throughout the period of flooding conditions (see Table 4 – full sample results); however,, the results for livestock tend to matter for urban households while that of agricultural tools relate to rural households. These results reflect the existence of plausible trade-offs between using some assets to smooth consumption expenditures and holding on to others for recovery at a later period.

As shown by our results, different asset portfolios can bolster or restrict the buffering capacity of households against climate shocks depending on some specific contexts. Thus, programs initiated to build the resilience of households against floods should consider the varying relationships among asset portfolios, flood intensities, and spatial location of households. Understanding these relationships is fundamental to enhancing design and effectiveness of various asset accumulation interventions to the negative welfare effects of protracted crises.

This study was limited in a number of ways. First, we were unable to explicitly account for other direct linkages of the effect of floods on consumption, such as crop and livestock losses which can also indirectly affect the accumulation of some assets. This further feeds into the concern for endogeneity bringing to the fore the need for future studies to properly account for it in order to precisely estimate the flood effects. Second, the study did not examine in detail the role of different components of the various asset types, especially for livestock, where the buffering effects may vary for different species under different flood durations. Finally, the study did not consider the consequences of climate shocks across different economic sectors as well as which asset portfolios may be important for households across the various economic sectors. This could have enabled comparisons between households classified under various sectors like agriculture, industry and services.

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Appendices
Appendix A:

Table A1: Asset portfolios and well-being variables from the GSEPS

Asset Portfolios	Dimensions	Number	Value
Livestock	Drought Animal	yes	yes
	Cattle	yes	yes
	Sheep	yes	yes
	Goats	yes	yes
	Pigs	yes	yes
	Rabbits	yes	yes
	Chickens/Roasters	yes	yes
	Other farm Animals	yes	yes
Agric Equipment			
	Tractor - 2 & 4 wheel	yes	yes
	Harrow	yes	yes
	Tiller	yes	yes
	water pump	yes	yes
	irrigation pipe	yes	yes
	Spraying machine	yes	yes
	Outboard motor	yes	yes
	Plough	yes	yes
	Traller/cart	yes	yes
	Canoe	yes	yes
	Others /1	yes	yes
Non-Agricultural land	Ownership	yes	yes
Financial Assets	savings (home and bank)	-	yes
Business Assets	Ownership of:		
	land or building	-	yes (% HH shares)
	Transport equipment	-	yes (% HH shares)
	machinery	-	yes (% HH shares)
	other Assets	-	yes (% HH shares)
Consumer durables	43 household durable goods	Yes	Yes

Note: All variables are captured in wave 1, 2 and 3 of the Ghana Socioeconomic Panel Survey (GSEPS).
/1: Include - hoe, axe, rake, pick axe, sickle/reaping hook, cutlass.

Table A2: Effect of Household Total asset portfolio as a buffering mechanism against climate shocks (food consumption expenses)

Real Food Consumption Expenditures (p.a.e)	Urban sample			Rural sample		
	SPEI 12	SPEI 24	SPEI 48	SPEI 12	SPEI 24	SPEI 48
SPEI	-0.1972	-0.3137***	-1.1352***	-0.1765	-0.6726***	-1.2417***
	(0.1395)	(0.1195)	(0.1372)	(0.1390)	(0.1144)	(0.1128)
Household Total Asset (log)	0.1397***	0.1304***	0.0505***	0.1940***	0.1638***	0.1009***
	(0.0102)	(0.0118)	(0.0148)	(0.0095)	(0.0103)	(0.0124)
SPEI*Total Asset (interaction)	-0.0158	-0.0006	0.0904***	-0.0276	0.0328**	0.0990***
	(0.0186)	(0.0158)	(0.0174)	(0.0199)	(0.0167)	(0.0158)
In-transfers to HH (dummy)	-0.4200***	-0.4266***	-0.4013***	-0.4932***	-0.4628***	-0.4535***
	(0.1249)	(0.1241)	(0.1253)	(0.1738)	(0.1738)	(0.1616)
Dependency ratio	0.0546	0.0600	0.0349	-0.0103	-0.0140	-0.0264
	(0.0614)	(0.0607)	(0.0591)	(0.0563)	(0.0554)	(0.0534)
Number of elderly	-0.0905**	-0.0892**	-0.0637*	-0.0922***	-0.0895***	-0.0686**
	(0.0384)	(0.0382)	(0.0382)	(0.0328)	(0.0325)	(0.0316)
Number of children	-0.0323	-0.0445**	-0.0341	-0.0250	-0.0310	-0.0202
	(0.0224)	(0.0220)	(0.0218)	(0.0241)	(0.0239)	(0.0236)
Household size	0.0569***	0.0618***	0.0610***	0.0206	0.0250	0.0168
	(0.0166)	(0.0163)	(0.0161)	(0.0191)	(0.0189)	(0.0187)
HoH age (number of years)	0.0168***	0.0168***	0.0125**	0.0194***	0.0190***	0.0147***
	(0.0051)	(0.0052)	(0.0052)	(0.0050)	(0.0050)	(0.0049)
HoH age squared (x0.01)	-0.0107**	-0.0113**	-0.0089*	-0.0113**	-0.0113**	-0.0085*
	(0.0052)	(0.0052)	(0.0053)	(0.0050)	(0.0050)	(0.0048)
HoH female (base is male)	0.0761***	0.0788***	0.0595**	0.1015***	0.0983***	0.1290***
	(0.0274)	(0.0273)	(0.0268)	(0.0297)	(0.0295)	(0.0287)
Employment status: (base is unemployed)						
Paid employee	-0.2196***	-0.1849***	-0.1136*	-0.0220	0.0080	0.1142*
	(0.0620)	(0.0620)	(0.0620)	(0.0662)	(0.0662)	(0.0660)
Household farm	-0.1641**	-0.1770***	-0.1370**	0.1400**	0.1503***	0.2150***
	(0.0690)	(0.0687)	(0.0682)	(0.0585)	(0.0579)	(0.0576)
Non-farm farm	-0.0888	-0.0737	-0.0196	0.1798***	0.1997***	0.2576***
	(0.0594)	(0.0594)	(0.0593)	(0.0619)	(0.0611)	(0.0607)
Unpaid housework	-0.1112	-0.1113	-0.0458	0.2425***	0.2549***	0.3026***
	(0.0685)	(0.0683)	(0.0682)	(0.0736)	(0.0731)	(0.0724)
Not in labour market	-0.2090***	-0.1880***	-0.1282*	0.0635	0.0809	0.1151**
	(0.0676)	(0.0675)	(0.0671)	(0.0583)	(0.0581)	(0.0579)
missing or other	0.0754	0.0732	0.0297	0.6165***	0.6127***	0.5941***
	(0.1000)	(0.0992)	(0.0979)	(0.0943)	(0.0942)	(0.0923)
No. of members employed	0.0337	0.0322	0.0388*	0.0226	0.0243	0.0254
	(0.0212)	(0.0211)	(0.0213)	(0.0189)	(0.0187)	(0.0186)
Educational qualification (base is no education)						
Basic or Middle School Certificate	0.0149	0.0218	0.0338	-0.0330	-0.0222	-0.0131
	(0.0340)	(0.0340)	(0.0336)	(0.0305)	(0.0306)	(0.0301)
Vocational/Technical	-0.0575	-0.0236	-0.0084	-0.0249	0.0381	0.0561
	(0.0513)	(0.0516)	(0.0518)	(0.0773)	(0.0776)	(0.0745)
Secondary /O&A level	-0.0332	-0.0174	-0.0120	-0.0503	-0.0580	-0.0885
	(0.0489)	(0.0488)	(0.0480)	(0.0733)	(0.0727)	(0.0721)
Teacher /HND	0.0340	0.0385	0.0627	0.0005	0.0390	0.0545
	(0.0725)	(0.0712)	(0.0681)	(0.1052)	(0.1016)	(0.0978)
Degree (Bachelors/masters)	0.0629	0.0716	0.0746	-0.0065	0.0213	0.0008
	(0.0744)	(0.0738)	(0.0729)	(0.1207)	(0.1226)	(0.1241)
others & missing	-0.0977**	-0.0974**	-0.0865**	-0.2130***	-0.2006***	-0.2421***
	(0.0428)	(0.0421)	(0.0413)	(0.0336)	(0.0335)	(0.0328)
Constant	3.8928***	4.0194***	4.8210***	3.2904***	3.5145***	4.1845***

	(0.1894)	(0.1967)	(0.2112)	(0.2239)	(0.2249)	(0.2214)
District Dummies	NO	NO	NO	NO	NO	NO
N	4,711	4,711	4,711	6,769	6,769	6,769
Chi2	664.08	734.90	870.96	1,253.02	1,516.94	1,933.05

* $p<0.1$; ** $p<0.05$; *** $p<0.01$