Downpours of Deprivation: Exploring the Impact of Excess Rainfall Shocks on Perceived Relative Deprivation in Peru

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Abstract

Perceptions of relative deprivation or feelings of relative poverty affect a range of economic and behavioral outcomes, such as support for redistribution, political attitudes, hostility, and risky behavior. In this paper, I test whether *covariate shocks*-like excess rainfall shocks can change perceptions of relative deprivation in a developing country context. Using household-level longitudinal data for Peru, I provide novel evidence showing that exposure to excess rainfall shocks increases the likelihood that households perceive their standard of living to be worse off relative to the other households in the locality. Two fundamental mechanisms could explain this- firstly, the differential effect of excess rainfall shocks across objective outcomes suggests a widening economic gap reflected in standard relative deprivation measures, and secondly, misperceptions about the losses of other households within a locality could explain the increase in perceived relative deprivation. The impact is particularly larger for historically underprivileged and less developed communities, possibly due to limited options of consumption smoothing. I show that social protection programs, such as conditional cash transfers and in-kind food assistance programs, can attenuate the effect of rainfall shocks on perceived relative deprivation. Finally, I show an association between perceived relative deprivation and political beliefs related to the functioning of democracy and support for authoritarian regimes in Peru.

Keywords: Relative Deprivation, Poverty and Inequality, Rainfall Shocks, Political Beliefs
JEL Codes: D63, D10, I31, Q54

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1 Introduction

Social positions relative to others matter to people. Kosec and Mo (2021) argue that equity theory, relative deprivation theory, and social comparison theory (Adams, 1965; Crosby, 1976; Walker and Smith, 2002; Festinger, 1954; Suls and Wheeler, 2000) advocate that individuals *"are acutely affected by comparison with others"*. While the literature from sociology and psychology has traditionally emphasized the importance of reference points, a recent growing body in economic research provides empirical evidence on how perceptions of social position or perceived relative deprivation [1] affect various critical outcomes. For example, perception of social position or relative deprivation can affect views on inequality (Hvidberg et al., 2020), shift political attitudes (Healy et al., 2017; Kosec and Mo, 2021), lead to poorer physical and mental health (Mishra and Carleton, 2015), increase hostility or aggressive behavior (Greitemeyer and Sagioglou, 2019), change risk tolerance (Mo, 2018), feelings of overall subjective well-being and life satisfaction (Ravallion and Lokshin, 2010), and support for redistribution policies (Alesina and La Ferrara, 2005; Clark and d'Ambrosio, 2015; Knell and Stix, 2020, 2021; Fehr et al., 2022; Hoy and Mager, 2021).

However, the evidence from recent literature is skewed towards developed countries. It primarily uses a combination of dedicated surveys with experimental set-ups alongside rich administrative records (e.g., income history, tax records, etc.). Importantly, this strand of research focuses on the effect of individual transitory income shocks (such as unemployment, disability, hospitalization, or promotions) on perceptions of social positions within a given reference group (Hvidberg et al., 2020). While a recent emerging literature does focus on developing countries, most of it provides evidence from *experimental* set-ups, showing the role of perceived relative deprivation in shaping political attitudes and risky behavior (Healy et al., 2017; Kosec and Mo, 2021; Mo, 2018). There is, however, very little evidence on determinants of perceived relative deprivation in a non-experimental or a real-world setting in developing country contexts. Moreover, less is known about whether covariate shocks can be an important determinant of perceived relative deprivation.

[1] Perceptions of social position in this context reflect individual perceptions of relative disadvantage. In particular, the literature in this area investigates whether an individual or a household perceives itself to be ranked lower (or worse off) than others in a given reference group. This is referred to as perceived relative deprivation or perceptions of relative poverty, defined in comparison to other people's standing in the economy (Eskelinen, 2011; Kosec et al., 2021).

In this paper, I investigate whether covariate shocks — in particular, excess rainfall shocks — can affect perceived relative deprivation in the context of a developing country-Peru. With climate change, covariate shocks in the form of extreme weather shocks have become more widespread in recent decades. Extreme weather has adverse consequences for a wide range of economic, health, and social outcomes (Dell et al., 2012; Zhang et al., 2017; Schlenker et al., 2009; Aragón et al., 2021; Deschênes and Greenstone, 2011; Iyer and Topalova, 2014; Blakeslee and Fishman, 2013). However, we know little about how these covariate shocks affect perceptions of relative deprivation. While one can argue that negative covariate shocks can increase both absolute and relative poverty, their effect on perceived relative deprivation is less straightforward. While idiosyncratic shocks could make households clearly worse off and thus make them perceive they are relatively deprived, this hypothesis in the context of covariate shocks is *ambiguous* as a covariate shock affects all contiguously placed households within a geographic area. In such a context, relative losses could be key in shaping perceptions of relative deprivation. Alongside relative losses, perceptions of possibilities of upward economic mobility or economic aspirations could be key in determining perceptions of relative deprivation through unmet aspirations (Genicot and Ray, 2017; Acemoglu et al., 2018; Healy et al., 2017).

I study the impact of excess rainfall shocks on perceived relative deprivation in the context of Peru, which is considered one of the most vulnerable countries to climate change in the world (Stern, 2007; Tambet and Stopnitzky, 2021). I focus on excess rainfall deviations due to their increasing relevance in recent decades, especially in Peru. Heavy abnormal rainfalls have increased the frequency of deadly landslides, mudslides, floods, flash floods, and other heavy rainfall-induced emergencies across Peru, resulting in heavy economic losses and casualties (USAID, 2017; French and Mechler, 2017). In general, it is important to understand the role of covariate shocks because they are more widespread than idiosyncratic shocks. Moreover, covariate shocks in the form of extreme weather shocks are becoming more frequent and intense in nature.

I use an unbalanced panel of households over a period of 13 years. Specifically, I use the 2007-2019 rounds of the Peruvian National Household Survey (*Encuesta Nacional de Hogares*, ENAHO), which includes a rich module on household perceptions of economic positions as well as confidence in public institutions. I create a measure of perceived relative deprivation using questions about households' perceptions of how their own standard of living has changed ("got worse", "same", or "got better") vis-à-vis other households in its locality ("got worse", "same", or "got better"), in the past 12 months from the time of interview. I match households' responses with local weather data. I use the geo-locations of each household (specific to the village centroid in rural areas and to the neighborhood block in urban areas) and the specific interview date of each household (to estimate weather shocks in the 12-month period prior to the survey date). My primary weather variable is a widely used measure of rainfall shock: an indicator variable for whether a household had experienced a cumulative rainfall over the previous 12 months that exceeded the average long-run (past 20 years) rainfall by more than some alternative harmful threshold (for example, Rosales-Rueda (2018); Riley (2018)). In particular, I consider thresholds of 1, 1.5, 2, 2.5, ..., 4 of the long-run standard deviation (S.D.) of rainfall. These indicator variables account for any potential non-linear effects of excess rainfall on perceived relative deprivation. My identification strategy exploits *within-household* variation in exposure to excess rainfall shocks, conditional on a set of household characteristics and district, year, and month-of-interview fixed effects.

I conceptualize that excess rainfall shocks could lead to changes in perceived relative deprivation through two key channels. First, it might be the case that rainfall shocks do have differential effects across households within localities, thus making a set of vulnerable households *actually* more deprived than other households within a locality. This could widen economic gaps within a locality and lead to perceived relative deprivation. In other words, perceived relative deprivation could indeed reflect households' objective losses. Second, given its covariate nature, excess rainfall shocks could similarly affect all households within a locality (i.e., no actual changes in relative well-being within communities). However, perceptions of relative deprivation could be guided by possible misperceptions about the losses of other households within a locality.

Conditional on household, month of interview, and year fixed effects, and controlling for a set of household characteristics, I find that exposure to extreme excess rainfall shocks increases the likelihood of households perceiving their standard of living to be worse off relative to other households in the locality or community. For example, I find that positive deviations in rainfall from the long-run mean by more than 2.5 times the long-run standard deviation increase the likelihood of perceived relative deprivation by 1.25 percentage points (6.2% increase). Importantly, the point estimates are larger and remain statistically significant when considering more intense shocks (i.e., when rainfall deviates by more S.D. from its mean).

I then explore possible mechanisms. I first show that excess rainfall shocks affect key objective outcomes. I show that rainfall shocks reduce household per capita expenditure[2]. For example, deviation in rainfall above its long-run mean by more than 2.5 (long-run) S.D. reduces household consumption by 2.11%. Then, I show that there is a differential effect amongst more vulnerable households. Using baseline household poverty status, I find that poorer households suffer a larger decline in household consumption. Furthermore, I find that this differential effect is reflected in standard measures of *objective* relative deprivation, such as the Yitzhaki or Stark indexes (Stark, 1984; Yitzhaki, 1979). Intuitively, these measures capture the average gaps between a household's consumption (or other welfare measure) with respect to the consumption of those in the same reference group (Hey and Lambert, 1980; Yitzhaki, 1979). I find that excess rainfall shocks actually widen the economic gap (in terms of household consumption) within localities, as measured by the Yitzhaki or Stark measures of relative deprivation.

Since poor households seem to experience larger losses than non-poor households objectively, I also test whether this translates into differential effects on perceived relative deprivation. Using baseline poverty status, I find that actually *both* poor and non-poor households perceive relative deprivation in the face of a shock, though the effects on non-poor households are somewhat smaller. While the differential losses and widening economic gap between the poor and non-poor households could explain perceived relative deprivation for poor households, it does not fully explain increases in perceptions of relative deprivation amongst the better-off households.

Next, I look into the role of misperceptions of other households' losses in explaining the effect of excess rainfall shocks on perceived relative deprivation. Potentially households might under or overestimate how weather shocks affect neighbors (or others in their reference group), affecting how they perceive their status within their communities. First, I show that extreme positive rainfall shocks do not only affect individual households but negatively affect all others in their reference groups. In particular, I find similar negative effects of rainfall shocks on neighbors' consumption measured by leave-one-out average household per capita expenditure [3]. This explains

[2]For convenience, I will refer to household per capita expenditure as household consumption throughout the paper.

[3]This is the mean household per capita expenditure of all sampled households within a district (rural or urban separately), excluding the household's consumption.

that excess rainfall shocks also affect other households in the locality in terms of consumption losses, reassuring the covariate nature of the shock. However, I find that even with similar losses for other households within the locality in the face of a shock, a given household is more likely to perceive that the standard of living of others in their locality has remained the "same" or got "better" in the course of the last year. This evidence indicates that there are misperceptions about the losses of other households within a locality, and hence, possibly explains an increase in perceived relative deprivation due to an excess rainfall shock.

I document heterogeneous effects in terms of two key aspects- the indigenous population and low levels of local development. The indigenous population in Peru continues to face discrimination in various ways that potentially limit their capacity to smooth consumption in the face of a shock. Additionally, the ability to smooth consumption could be limited within areas with low levels of overall economic development and thus can shape perceived relative deprivation. Heterogeneity analyses point out that indigenous households are more likely to perceive relative deprivation in the face of a shock than non-indigenous households. Additionally, I find that households living in districts with a baseline Human Development Index (HDI) lower than the median HDI of all districts in Peru are more likely to perceive relative deprivation. This suggests that associations with historically isolated communities and lower levels of local development augment perceptions of relative deprivation in the face of a shock.

Next, I explore the role of social protection programs in mitigating perceived relative deprivation. For this, I look into the conditional cash transfer program *Juntos* [4] and access to the Food Assistance Programs. Based on the data in the ENAHO, I identify the households that had access to either Juntos or food assistance programs at the baseline year of the survey. I find that those without access to these programs are more likely to perceive relative deprivation in the face of a shock relative to beneficiary households. Thus, cash and in-kind transfer programs could be vital in helping mitigate perceptions of relative deprivation as households experience an excess rainfall shock.

[4]The Peruvian Juntos is a conditional cash transfer program with eligibility based on poverty scores. Transfers are conditional on households meeting certain educational attendance requirements (for children between 6-14 age) and health checkups (for children between 0-5 and pregnant women/nursing mothers). As of 2023, the program transfers 200 Peruvian Soles (roughly 54 USD) every other month to those meeting the required criteria.

I also show that my results are robust to several alternative specifications. The findings are robust to alternate measures of perceived relative deprivation. Second, the effect of excess rainfall-related shocks on perceived relative deprivation is robust to alternate shock measures. I use excess rainfall-related *emergencies* in Peru, like floods, mudslides, landslides, and heavy rainfall scenarios. I find that exposure to such emergency events that affect all households within a locality also leads to an increase in perceived relative deprivation. The effect of excess rainfall shocks on perceived relative deprivation is also robust to a range of potential harmful thresholds of rainfall (i.e., deviations in terms of the number of S.D. with respect to the long-term average rainfall) and measures of self-reported exposure to similar natural disaster events. I also do not find any evidence of changes in sample composition and endogenous migration. Finally, I also find that lead-year rainfall deviations do not affect changes in perceived relative deprivation. This suggests that areas that perceived relative deprivation had similar trends in areas that will experience *future* rainfall shocks relative to those that will not. This allows me to rule out that rainfall shocks capture unobserved determinants of perceived relative deprivation that vary systematically across households and/or geographic areas. It also suggests that households are unable to anticipate upcoming weather shocks and preemptively adjust to them.

Finally, I demonstrate the policy relevance and significance of perceived relative deprivation in the Peruvian context by providing evidence of a strong relationship between perceived relative deprivation and measures of political attitudes or trust- the belief that democracy functions well in Peru, as well as a preference for authoritarian regimes over a democratic regime. These outcomes are closely related to satisfaction of democracy, which is a widely used measure to capture political trust and confidence in institutions (Citrin and Stoker, 2018). Low levels of political trust indicate a lack of confidence in public institutions, affecting policy preferences, conflict, compliance with laws and civic participation, amongst other outcomes (Citrin and Stoker, 2018; Buhaug et al., 2015). Using a panel of households and a fixed-effects estimation strategy, thus exploiting within-household variations, I find that households perceiving relative deprivation are more likely to report democracy functions "poorly" or "very poorly" in Peru; additionally, these households are also more likely to prefer "authoritarian regimes over democratic ones, in some circumstances." These results help explain perceived relative deprivation as one of the alternate explanations for political mistrust in Peru.

My research provides new evidence and complements existing knowledge related to perceived relative deprivation through different aspects. To the best of my knowledge, this is the first paper to study perceived relative deprivation in a non-experimental set-up and in a developing country setting. This adds to the existing literature which studies perceived relative deprivation in developing countries through experimental set-ups (Kosec and Mo, 2021; Kosec et al., 2021; Healy et al., 2017).The recent experimental literature primarily relies on *poverty priming* [5]. One of the critical limitations of these studies is that they only *temporarily* create perceptions of relative deprivation, which could be very different from a situation where individuals or households are actually deprived in reality (Healy et al., 2017). Using a real-world setting, this paper shows that excess rainfall shocks can *also* lead to changes in perceived relative deprivation. This is most likely explained by an increase in relative deprivation through the differential impact of weather shocks across the most vulnerable and less vulnerable households and misperceptions about the losses of other households within a locality.

Secondly, I study the role of *covariate shocks* in shaping household perceptions about relative social positions. This is key because the current literature studying perceptions of social positions attributes the role of idiosyncratic shocks in shaping perceptions of social positions (Hvidberg et al., 2020). It is relatively clear as to why idiosyncratic shocks may change perceptions of social positions as they are household-specific and make a household relatively worse off or better off than other neighboring households, depending on the nature of the shock. However, this is unclear in the case of covariate shocks, as all households within a locality experience this shock. Moreover, a major challenge with covariate or community-level shocks is that they impact all households in a given area, thereby significantly restricting the potential for mutual insurance. This is not the case with idiosyncratic shocks, which affect individual households and, therefore, can be mutually insured within communities (Günther and Harttgen, 2009; Bhattamishra and Barrett, 2008). However, it is easier to target covariate shocks as it is most often located within an easily identifiable geographic area or region (Günther and Harttgen, 2009).

[5] Poverty priming involves inducing or "priming" a set of participants to feel relatively poor, and the other set is made to feel that their incomes are more typical or close to the median (Kosec and Mo, 2021; Kosec et al., 2021; Healy et al., 2017; Mo, 2018)

Third, I contribute by studying the role of redistributive policies, such as cash transfers and food assistance programs, in attenuating perceived relative deprivation. There is scant evidence on whether access to redistribution can effectively mitigate perceived relative deprivation. Access to the Peruvian conditional transfer program Juntos and food assistance programs can effectively mitigate perceived relative deprivation in the face of extreme rainfall shocks. This is a key and novel result with regard to the role of redistributive policies in weakening perceived relative deprivation in a developing country setting.

Section 2 provides a context on the excess rainfall situation and its consequences, focusing on Peru, alongside a discussion on actual inequality in Peru. Section 3 discusses the various datasets that have been used. Section 4 describes the empirical strategy followed by the discussion of the main results in section 5. Section 6 explains the mechanisms, followed by evidence on the role of social programs in sections 7.1 and 7.2. Section 8 discusses the robustness checks. Finally, section 9 provides evidence related to the role of perceived relative deprivation in shaping political attitudes in the context of Peru. Section 10 concludes.

2 Context

In recent times, extreme weather events have become a significant source of adverse covariate shocks, occurring more frequently and have become more widespread. One such common weather extreme has been *excess rainfall*-related events. Excessive rainfall-related emergencies such as floods, flash floods, and landslides have risen globally, affecting even some of the most developed and populous regions. Examples of such heavy rainfall-related emergencies include floods in Western Europe (Tradowsky et al., 2023), landslides in California, USA (Handwerger et al., 2019), and increased flood risks in Bangladesh, China, and India (Mukherjee et al., 2018; Kundzewicz et al., 2014). Though other meteorological, topographical, and other location-specific factors could augment the possibilities of a flood, flash flood, or landslide event, excess rainfall remains a key common factor behind such related hazards (Mukherjee et al., 2018; Tradowsky et al., 2023; Kundzewicz et al., 2014; Ávila et al., 2016; Maqtan et al., 2022; Vox, 2023).

Extreme weather events have become common and widespread in Peru as well. Peru is considered one of the most vulnerable countries to climate change in the world (Stern, 2007;

Tambet and Stopnitzky, 2021). Extreme weather-related emergencies like heavy rainfall, floods, frost, cold waves, and droughts have increased in Peru in recent decades (World Bank, 2008). Peru has had much more excess rainfall-related weather emergencies like floods, flash floods, landslides, and mudslides, than other types of weather-related extreme events (Guha-Sapir, 2020). For example, figure A1 shows that the share of specific weather related emergency responses, and excess rainfall related events tend to have higher emergencies than drought or frosts.

An extensive body of work highlights the negative consequences of heavy rainfall-related weather events. It affects populations both in rural and urban areas through channels of agricultural income, food security, child health and infectious diseases and vector-borne illnesses, human capital formation, armed conflict, and preventing people from working and destroying property (Oskorouchi and Sousa-Poza, 2021; Sajid and Bevis, 2021; Ghimire and Ferreira, 2016; Rosales-Rueda, 2018; Dimitrova and Muttarak, 2020; Riley, 2018).

In the case of Peru, heavy rainfall-related events have had widespread consequences and have affected large sections of the population through losses in agriculture and damages in housing, water and sanitation, health, and even education and transportation sectors (French and Mechler, 2017). For example, the 2017 floods in Peru affected approximately 40,000 hectares of crops-affecting close to 7000 agricultural producers, a large majority of which were small farmers (USAID, 2017). Months of heavy rainfall have affected many urban and peri-urban populations through rainfall-related hazards like floods, mudslides, and landslides. Excessive rain has also restricted access to safe drinking water and sanitation infrastructure, increasing the chances of diseases like diarrhea, dengue, zika, and other harmful vector-borne diseases (USAID, 2017; French and Mechler, 2017). There is substantial evidence in the climate change literature suggesting heavy rainfall will become increasingly common in the future (Cai et al., 2014; Gründemann et al., 2022). This underscores the importance of studying the varied consequences of such extreme events, which affect a large section of the population worldwide.

Alongside increasing weather extremes, there has been a growing concern regarding inequality, particularly after the surge in economic inequality caused by the pandemic. Inequality has surged in recent years and remains prevalent in Peru (figure A2). Peru has remained one of the most unequal countries in the world in the last three decades (figures A3 and A4). High inequality is often the breeding ground for political instability, lack of democratic consolidation, and fiscal volatility

(Alesina and Perotti, 1996; Dutt and Mitra, 2008; Acemoglu and Robinson, 2001). Unfortunately, Peru has experienced all these issues in the last three decades. Corruption, political clashes, impeachments, and failed coup attempts have added to the uncertainty in the country, with Peru having one of the highest levels of political mistrust in Latin America (figure A5). Despite being a democratic country, Peru has been classified as a "flawed democracy" or an "authoritarian regime" due to the continued political uncertainties over several decades. This classification is significant given its past history of suppressive autocratic and military regimes.

Negative economic shocks can exacerbate existing economic inequality. Since extreme weather events are increasingly becoming a major cause of negative economic shocks, studying their potential distributional consequences- both in terms of perceived relative deprivation and objective relative deprivation remains crucial.

3 Data

3.1 Encuesta Nacional de Hogares (ENAHO)

The ENAHO is a detailed household survey collected annually by the Peruvian National Statistics Office (*Instituto Nacional de Estadística e Informática* - INEI). In particular, my analysis is based on 13 rounds of the ENAHO (2007-2019). The ENAHO provides data on a panel (longitudinal) of households. In particular, the ENAHO provides these panel data in waves of 5 years. In this paper, I use 6 of these waves that span over 2007-2011 (wave-1), 2011-2015 (wave-2), 2012-2016 (wave-3), 2013-2017 (wave-4), 2014-2018 (wave-5) and 2015-2019 (wave-6). For this study, I use an unbalanced panel of households which are surveyed at least twice between 2007-2019. The households in the analytical sample are spread across the three main regions of Peru (the coastal region, the highlands, and the Amazonian jungle; see figure A6).

The ENAHO collects rich data on a wide range of topics, including information on household and individual-specific characteristics; assets or dwelling characteristics; health outcomes; information on agricultural and livestock-related activities at the household level; income and wage information; and detailed information on governance-related attitudes and household perceptions.

In this paper, I calculate a perceived relative deprivation measure drawn from two particular questions asked to the household head in the governance module of the survey (see Table 1). The first question is: “In the course of the past year, has the standard of living of households in your locality or community got better, remained the same, or got worse?” (where “got better”, “remained same” and “got worse” are provided as options to answer the question). The second question is: “In the course of the last year, has the standard of living of *your* household- got better, remained the same, or got worse?”.

I construct a simple binary measure of perception of relative deprivation, which takes value one if the household perceives itself to be worse-off in terms of standard of living compared to the households in its locality or community, and zero if the household perceives its standard of living to remain the same or is better off in comparison to the households in the locality or community (Table 1). The resulting variable takes value one in three alternative situations: [1] if the household reports that its own standard of living has remained the same but has improved for other households in its locality or community; [2] if the household reports that its own standard of living has worsened in the past year but has improved for other households in its locality or community; or [3] if the household reports its own standard of living has worsened in the past year but has remained the same for other households in its locality or community. The binary measure takes a value of zero in all other possible cases [6].

Table 1: Constructing Perceived Relative Deprivation Measure

Perception of Relative Deprivation		In the course of the last year, the standard of living of households in your locality or community		
		got better	same	worse
In the course of last year, the standard of living of your household?	got better	same (=0)	hh perception- better off (=0)	hh perception- better off (=0)
	same	*hh perception- worse off (=1)*	same (=0)	hh perception- better off (=0)
	got worse	*hh perception- worse off (=1)*	*hh perception worse off (=1)*	same (=0)

[6] Specifically, this is the case when either of the following holds: [1] a household perceives its standard of living has remained the same while others have remained the same or worsened; [2] a household perceives its standard of living to have improved over the course of the past year, notwithstanding the perceived positions of other households.

3.2 Weather Data

Next, to construct the weather shock measure, I extract rainfall data from the Weather Hazards Group InfraRed Precipitation with Station Data (CHIRPS).[7] CHIRPS is a global dataset that provides high-resolution estimates of rainfall for 0.05 $\times$ 0.05-degree pixels. I match rainfall to households using GPS coordinates and interview dates from the ENAHO, thus constructing household-specific rainfall shocks.

Using the daily rainfall data, I construct the following excess rainfall shock measure-

$$ExcessRainfall_{idmt} = (R_{idmt} - LRMean_{idmt})/\sigma_{idmt} \tag{1}$$

where, R_{imdt} is observed cumulative rainfall in the past 12 months from the time of interview of household i, in district d, interviewed in month m of year t; $LRMean_{idmt}$ is household i's corresponding long-run mean (past 20 years) from the time of interview of the household; and σ_{idmt} is the corresponding long-run standard deviation.

$$Shock_{idmt} = \begin{cases} 1 & \text{if } ExcessRainfall_{idmt} \geq \lambda \\ 0 & \text{if } ExcessRainfall_{idmt} < \lambda \end{cases} \tag{2}$$

where λ takes alternative values (i.e., λ= 1, 1.5, 2, 2.5,.. 4 S.D.) that represent different harmful thresholds in terms of deviations of contemporaneous rainfall. As noted earlier, I am primarily interested in excess rainfall shocks as it is key to some of the weather-induced extreme hazards like floods, landslides, and mudslides (Ávila et al., 2016; Maqtan et al., 2022; Tradowsky et al., 2023; Vox, 2023). Such hazards are becoming increasingly prevalent in Peru. I also show that the measure of shock here is a strong predictor of exposure to heavy rainfall, floods, mudslides, and landslide-related emergencies in Peru.

In addition to using actual weather shock measures for excess rainfall shocks, as a robustness check, I also examine the impact of households' self-reported exposure to natural disasters. The governance module of the ENAHO asks respondents whether they had experienced natural disaster

[7] For a discussion of the CHIRPS dataset, please see Funk et al. (2015).

events in the past 12 months from the time of the interview. I use this response to create a binary variable of self-reported exposure to natural disasters. Since this measure can raise endogeneity concerns, I additionally construct a binary measure of exposure to natural disaster events which takes a value of one if at least 50% (i.e., the majority) of the households within a district in a given year report being exposed to a natural disaster.

3.3 Other Data Sources

Emergency Maps Data- The Peruvian Government provides detailed locations of emergency responses related to various emergency-related events like heavy rainfall, floods, mudslides, flash floods, landslides, fires, earthquakes, strong winds, environmental pollution, volcanic eruptions, and so on. The Instituto Nacional de Defensa Civil- INDECI (or National Institute of Civil Defense of Peru) is a public body under the Peruvian Government that coordinates emergency responses across Peru and is tasked with planning relief and rehabilitation responses alongside coordinating with local and regional governments to assess the extent of damage and supply relief and services in the case of an emergency. The institute of civil defense of Peru provides data on all such emergency responses since the year 2003 in the form of geographic coordinates (latitudes and longitudes) of all emergency responses and by type of emergency. This data allows us to test whether the measure of excess rainfall shock is a good proxy for heavy rainfall, floods, mudslides, flash floods, and landslide emergencies. As a part of the robustness check, I also examine the impact of exposure to such related emergency events on perceptions of relative deprivation.

Human Development Index (HDI) - The United Nations Development Program (2021) has published data of their calculations of the HDI at the district level for several years. In particular, it compiles data on three components of the HDI- life expectancy (as a proxy for general health conditions), average years of education (human capital), and per capita household expenditures (economic conditions). I use district-level HDI for the year 2007 as the baseline HDI in this case.

Table 2 provides summary statistics for households' relative deprivation and exposure to rainfall shocks.

Table 2: Descriptive Statistics

	Household Panel 2007-2019
Perceived Relative Deprivation (Dummy)	0.203
Excess Rainfall Shocks (Dummy)	
Rainfall Shock $\geq$ 1 S.D.	0.343
Rainfall Shock $\geq$ 1.5 S.D.	0.222
Rainfall Shock $\geq$ 2 S.D.	0.132
Rainfall Shock $\geq$ 2.5 S.D.	0.078
Rainfall Shock $\geq$ 3 S.D.	0.049
Rainfall Shock $\geq$ 3.5 S.D.	0.033
Rainfall Shock $\geq$ 4 S.D.	0.025
Mechanisms	
Annual Household Per Capita Expenditure	4643
Poor (Dummy, =1 if poor)	0.252
Relative Deprivation (Stark Measure)	0.315
Perception- other households in locality worse-off	0.117
Household Head Characteristics	
Male	0.510
Age (in years)	50.863
Education	
No education	0.095
Incomplete Primary	0.225
Complete Primary	0.172
Incomplete Secondary	0.127
Complete Secondary	0.189
Incomplete Technical	0.027
Complete Technical	0.069
Incomplete College	0.026
Complete College or higher	0.069
N. of obs.	139,587
N. of Households	44,193

4 Empirical Strategy

The main outcome of interest is how households change their perception of relative deprivation with exposure to excess rainfall shocks. I employ a household-level fixed effects estimation strategy to account for household-level unobserved time-fixed confounders that may affect exposure to weather shocks as well as perceptions of relative deprivation simultaneously, thus exploiting *within-household* variation in exposure to extreme rainfall shocks. Specifically, the following regression is estimated:

$$Y_{idmt} = \beta_1 Shock_{idmt} + \boldsymbol{X_{idmt}\delta} + \alpha_i + \gamma_t + \theta_m + \varepsilon_{idmt} \tag{3}$$

where Y_{idmt} is a binary measure of perceived relative deprivation- the main outcome of interest, as discussed above, of household i, in district d, interviewed in month m and year t. I also look into the effect of the excess rainfall shock on objective measures, like actual relative deprivation and consumption expenditure per capita, as a part of the mechanisms and to explain the effect of excess rainfall shock on perceived relative deprivation. $Shock_{idmt}$ is an indicator variable that equals 1 if the household experiences a excess rainfall shock in the past 12 months and 0 otherwise. X_{idmt} is a vector of household-level control variables. These controls include sex, age, age square, and education level fixed effects. α_i, γ_t and θ_m captures household, year and month fixed effects. Standard errors are clustered at the household level.

The coefficient of interest is β_1. The expected sign of β_1 is ambiguous in this case. Given the nature of the shock is covariate in this case, i.e., all households within the locality are exposed to a weather shock of similar intensity, which could potentially affect everyone economically. The identification strategy assumes-conditional on household, month of interview and year fixed effects, and other household-level controls– the incidence of excess rainfall shocks is exogenous to the perceived relative deprivation outcome. In summary, I exploit *within-household* variation, i.e., I compare the same household across years with and without excess rainfall shocks. As long as households are unable to anticipate fluctuations in extreme rainfall shocks, $\hat{\beta}_1$ will capture the causal effect of excess rainfall shocks on perceived relative deprivation.

5 Results

Effect on Perceived Relative deprivation

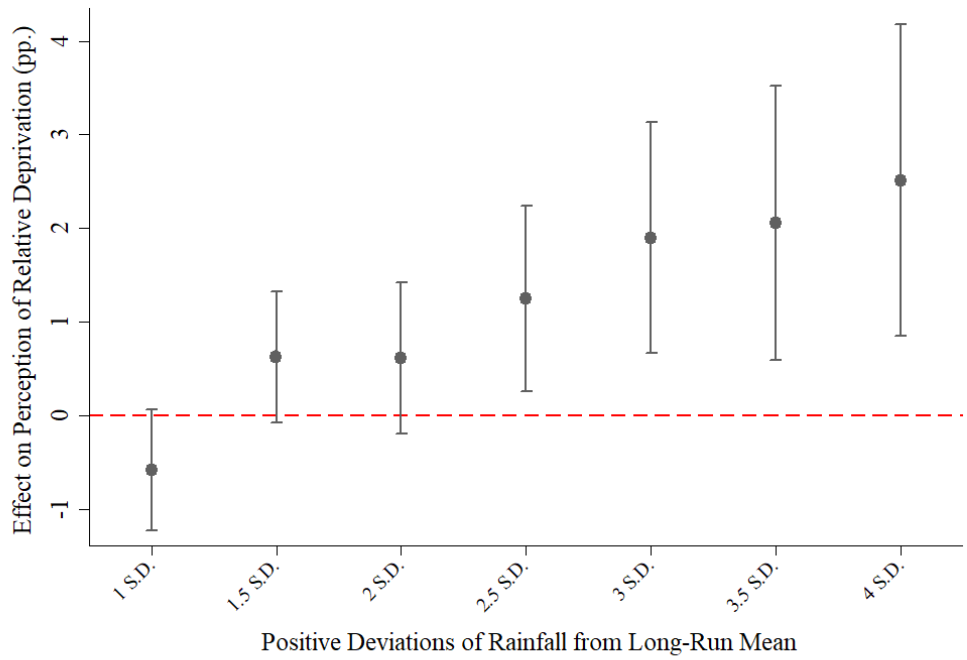
I find that exposure to positive rainfall shocks increases the likelihood of a household perceiving itself to be worse off than other households in the locality or community. For example, Table 3 shows that if rainfall in the past year deviates by more than 2.5 S.D. from its long-run mean, then the likelihood of the household perceiving its own standard of living to be worse off relative to other households in the locality or community increases by 1.25 percentage points (pp.). This is a large effect size: considering the sample average of the dependent variable, this translates into a 6.1% increase in the probability of feeling relatively deprived. Additionally, the magnitude of this effect increases as we choose more harmful thresholds, i.e., deviations greater than 3, 3.5, and 4 S.D. (Fig. 1). For instance, severe positive rainfall shocks of 4 S.D.s or more increase the likelihood of a household perceiving its standard of living to be worse off relative to other households in their locality or community by 2.5 percentage points.

Table 3: Effect on Perceived Relative Deprivation

	Dep. Var.: Perceived Relative Deprivation	
	(1)	(2)
Rainfall Shock	1.251**	1.249**
Deviation >= 2.5 S.D.	(0.506)	(0.505)
N. of obs.	139,587	139,587
N. of Households	44,193	44,193
Mean Dep Var	0.203	0.203
R2	0.367	0.368

Notes: Column (1) is without any controls. Column (2) includes controls- household head specific characteristic like sex of respondant (hh head), age, age square, education level fixed effects. All specifications include household, month of interview and year fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Effect of Positive Rainfall Shocks on Perceived Relative Deprivation



No. of observations: 139,587; Households: 44,193; Mean of Perceived Relative Deprivation: 0.20

6 Potential Mechanisms and Heterogeneity

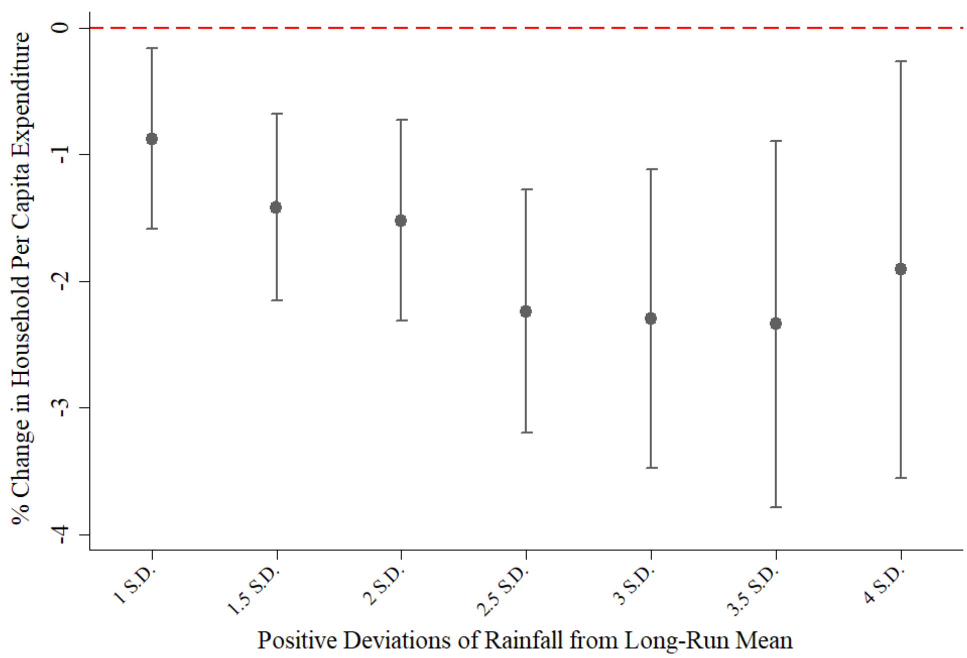
I conceptualize that the changes in perceived relative deprivation could be guided through two potential mechanisms. First, I examine whether rainfall shocks can increase *actual* relative deprivation. Rainfall shocks could potentially have differential effects and make some households objectively worse off than other households in the locality (altering their actual economic position within the community). Thus, the increase in *perceived* relative deprivation could be an artifact of an increase in actual relative deprivation. Second, an alternative channel could be that the weather shock of interest could affect all households similarly within a locality, but misperceptions about the losses of other households could guide perceptions of relative deprivation. I discuss these potential mechanisms in this section.

6.1 Effect on Objective Outcomes and Differential Effect by Baseline Economic Status

To explore the first potential mechanism (i.e., shocks affecting *perceived* relative deprivation through *actual* relative deprivation), I start by analyzing the effect of rainfall shocks on key objective outcomes, such as household per capita expenditure (household consumption). Next, I test whether rainfall shocks have differential impacts on objective outcomes that could affect perceived relative deprivation within communities.

I find that excess rainfall shocks reduce household per capita expenditure, one of the most widely used measures of economic welfare. This is in line with the literature exploring the effect of extreme weather shocks on income or consumption levels. Specifically, a deviation in contemporaneous rainfall from the long-run mean by 2.5 SDs, reduces household consumption by 2.13 % (Table 4).[8] The effect size increases in magnitude for higher harmful thresholds of deviations (Fig. 2).

Figure 2: Effect of Positive Rainfall Shocks on Household Per Capita Expenditure



No. of observations: 139,587; Households: 44,193; Mean of Household Per Capita Expenditure: 4643

As previously discussed, even when rainfall shocks affect all households within a given community, they can alter perceived relative deprivation if they affect households *differentially*; i.e., some households might experience more negative effects on objective outcomes than their

[8]This corresponds to an increase in the likelihood of a household falling below the poverty line by 1.3 percentage points (figure A7). Compared to the sample average of households below the poverty (25%), this translates to a 5.2% increase in poverty, which is a large effect.

Table 4: Effect on Household Per Capita Expenditure

	Log Household Per Capita Exp. (1)
Rainfall Shock	-2.110***
Deviation >= 2.5 S.D.	(0.529)
N. of obs.	139,587
N. of Households	44,193
Mean Dep Var	4643
R2	0.855

Notes: Controls include household head specific characteristics like sex of respondent (hh head), age, age square, education level fixed effects. All specifications include household, month of interview, and year fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

neighbors. This could be because households might have different levels of vulnerability, especially across poor and non-poor households. To investigate this possibility, I test whether rainfall shocks have heterogeneous effects by households' baseline poverty status [9]. Columns (1) of table 5 suggest that poor households (i.e., below the official poverty line) at baseline are more negatively affected by excess rainfall shocks than the non-poor households along objective outcomes. Specifically, for households classified as poor at baseline, a positive deviation in rainfall from its long-run mean by 2.5 SDs reduces household consumption by 3.2%. In comparison, a shock of similar intensity does not seem to affect non-poor households, suggesting that excess rainfall shocks disproportionately affect poor households. This differential effect on household consumption across poor and non-poor households hold across all thresholds of excess rainfall shock (figure A8).

Next, I investigate whether the differential effect of extreme rainfall shocks on objective outcomes translates into changes in *perceptions* about relative deprivation; i.e., are the poor also more likely to

[9] For this regression, I calculate households' "baseline" based on their poverty status in the first year in which they appear in the panel. Thus, I drop the observations from this baseline year from the regression sample. Because the empirical strategy discussed in Section 4 is based on *within* household variation, I also drop the observations from households that only appear once (besides the baseline year) in the panel. Therefore, this analysis only includes households that were surveyed for at least 3 years.

perceive they are relatively worse off? Column (2) of table 5 shows that *both* poor and non-poor households (by baseline poverty status) are more likely to perceive relative deprivation in the face of an extreme positive rainfall shock. However, poor households experience larger effects. Specifically, the probability that poor households perceive they are relatively deprived increases by 3.7 percentage points upon experiencing a shock. In contrast, the probability that non-poor households feel relatively deprived increases by 1.4 percentage points. In fact, this pattern of both poor and non-poor households perceiving relative deprivation is consistent for the other severe thresholds of excess rainfall shocks (Fig. A9). These findings are consistent with poor households experiencing larger losses across objective measures of well-being (such as consumption). However, given that non-poor households do not seem to experience objective losses, it does not explain why this group would also feel more relatively deprived [10].

Additionally, to determine whether extreme excess rainfall shocks widen the economic gap within the locality or community and lead to *actual* relative deprivation, I look into the effect of rainfall shocks on standard measures of relative deprivation (Stark, 1984; Yitzhaki, 1979). These standard measures of relative deprivation are based on using income differences within a reference group. However, alternate outcomes of interest like household consumption or wealth index could be used as well (Kafle et al., 2020). Since the perceived relative deprivation measure is based on perceived differences in the standard of living between the household and other households within a locality, I believe that using household consumption would be in line with our perception measure.

Following Stark (1984), let $F(y)$ denote the cumulative distribution of consumption y, and the $1 - F(y)$ is the percentage of households with higher consumption than y. The measure of relative deprivation for household i in a reference group n is defined as :

[10] It can be possibly argued that this increase in perceived relative deprivation for non-poor households is driven by the relatively vulnerable non-poor households (at baseline) that perhaps slip below poverty due to exposure to excess rainfall shocks. To address this, figures A10 and A11 show the effect of excess rainfall shocks on perceived relative deprivation on two separate sub-samples. Separately for households that *always* remain non-poor or above the poverty line and a combined sub-sample of households that always remain poor, as well as, *switch* status at least once, i.e., switch between non-poor and poor status. But fig. A10 shows that even households which remain always non-poor or above the poverty line *also* tend to perceive relative deprivation in the face of a shocks. This is suggesting that the increase in perceived relative deprivation for non-poor households are not just driven by the specific vulnerable non-poor households that possibly slip into poverty in the face of a shock.

Table 5: Differential Effect with Baseline Poverty Status

	Log Household Per Capita Exp. (1)	Perceived Relative Deprivation (2)
Rainfall Shock	-3.241**	3.686**
Deviation >= 2.5 S.D.	(1.654)	(1.430)
× Baseline Poverty Status	2.843	-2.267
[=1 if household is non-poor in baseline]	(1.777)	(1.595)
Effect for non-poors	-0.398	1.419*
at Baseline	(0.689)	(0.743)
N. of obs.	78,884	78,884
N. of Households	26,941	26,941
Mean Dep Var	4679	0.201
R2	0.869	0.391

Notes: Since I use the baseline poverty status, I leave out the baseline year of the household, thus, the number of observations reduces. Controls include household head-specific characteristics like sex of respondent (hh head), age, age square, and education level fixed effects. All specifications include household, month of interview and year fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

$$RD_{in}(y) = \int_{y_n^i}^{y_n^h} [1 - F(x)]\, dx \tag{4}$$

Here RD_{in} is the measure of relative deprivation for household i in reference group N. y_n^i is the consumption for household i, y_h^i is the highest consumption value in the reference group N, and $F(x)$ is the cumulative distribution of consumption in the reference group. Reference group in this context is defined as all households sampled within a given district in a given year (either all households within rural or urban areas, depending on the location of the household). Equation 4 can be written as the following:

$$RD_{in} = \mu_n[1 - \phi(Y_{in})] - Y_{in}[1 - F((Y_{in}))] \tag{5}$$

Here μ_n is the average consumption in the reference group, $\phi(Y_{in})$ is the proportion of households in the reference area with a consumption level higher than Y_{in} to the total consumption of all households in the reference area. $F(Y_{in})$ is the cumulative distribution of consumption in the reference group.

A similar measure of relative deprivation is the Yitzhaki measure of relative deprivation (Yitzhaki, 1979; Hey and Lambert, 1980; Podder, 1996). In this case, the Yitzhaki measure of relative deprivation for household i with N other households in its reference group [11] is defined as the following:

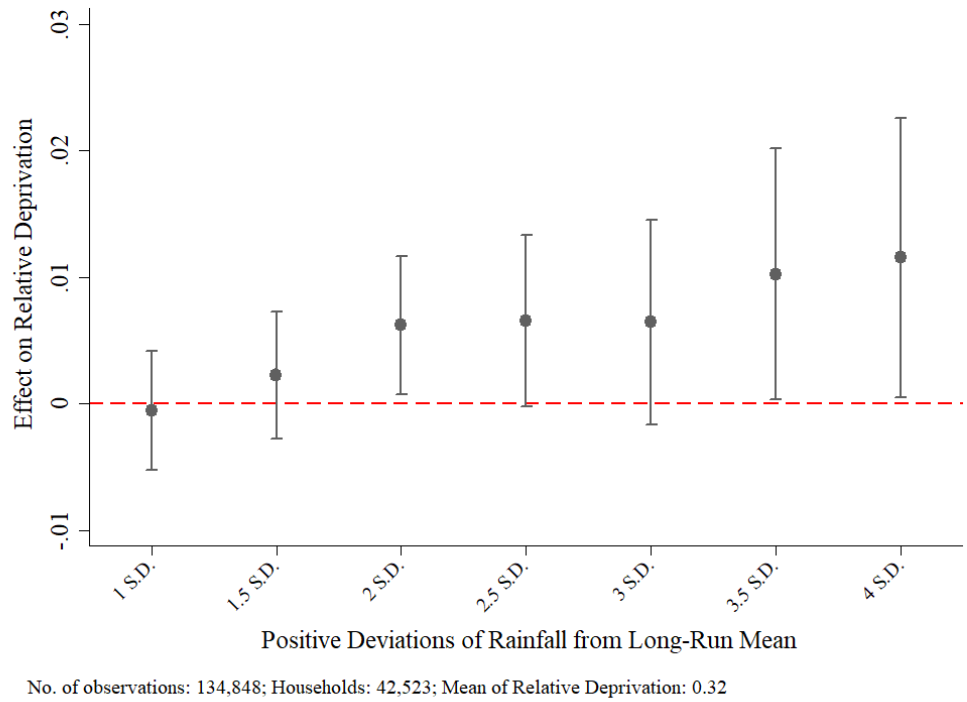
$$RD_i = 1/N \sum_{i \neq j} [ln(c_j) - ln(c_i)] ... \forall c_j > c_i \tag{6}$$

Here c is household per capita expenditure. Both these measures capture that the relative deprivation for household i is driven by the households with higher consumption than c_i. Using differences in log consumption expenditure per capita makes the measure scale-invariant, and dividing the size of the reference group makes the measure invariant to the reference group, and it also adjusts for the probability of making a comparison (Eibner and Evans, 2005; Podder, 1996; Hey and Lambert, 1980). Using this measure of relative deprivation, I find that heavy rainfall shocks widen the economic gap between households within its locality- as measured by per capita consumption expenditure (figure 3). Considering the sample average of the dependent variable, an excess rainfall shock above 2.5 S.D. from the long-run mean increases this objective measure of relative deprivation by 2.1%. The effect size is positive, statistically significant, and increases with higher harmful thresholds of the shock.

Overall, this explains that the differential effect of the excess rainfall shock across the poor and non-poor households translates into widening economic gaps within a locality- as measured by the measures of relative deprivation using objective outcomes like household per capita consumption. While this possibly explains the increase in perceptions of relative deprivation for poor households, it is unclear as to why the non-poor perceive relative deprivation (column (2) of table 5). Thus, we next look into the possible misperception channel as an additional mechanism to explain this finding alongside an increase in actual relative deprivation.

[11] The reference group here is similar to the Stark measure of relative deprivation. I consider all other households sampled within the district in a given year, either rural or urban, as the reference group of household i

Figure 3: Effect of Positive Rainfall Shocks on Relative Deprivation (Stark measure)

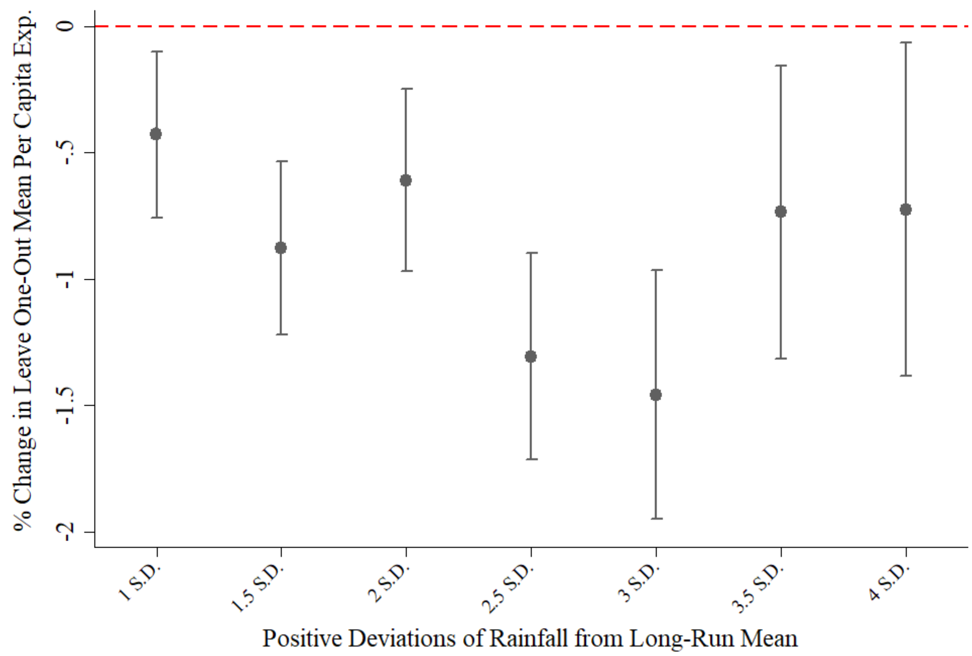


6.2 Role of Misperceptions of Other Households' Outcomes

As discussed earlier, excess rainfall shocks can affect perceived relative deprivation through another mechanism: households might feel relatively worse off if they have an incorrect sense of how these shocks affect others in their communities. For example, even if a household has only experienced mild objective losses from a rainfall shock, it might (incorrectly) believe that others around it have been completely unscathed and that its social standing in its community has been diminished.

To examine the role of possible misperceptions, I first check the impact of excess rainfall shocks on other households within a locality. For this, I construct a measure of relative consumption: the leave-one-out mean of per capita expenditure. The leave-one-out mean of household i is the average outcome of all other households within a community *excluding* household i. I estimate equation 3 using the leave-one-out mean of per capita expenditure (in logs). I find that the other households within a locality are also affected negatively due to a heavy rainfall shock. This can be seen in figure 4. Heavy rainfall shocks negatively affect the leave-one-out mean of per capita expenditure within a locality [12].

Figure 4: Effect of Positive Rainfall Shocks on Leave One-Out Mean Per Capita Exp. (in Log)



No. of observations: 138,590; Households: 43,745; Mean of Leave One-Out HH. Per Capita Exp.: 4652

Next, I test whether there are misperceptions about the losses of other households within the locality. For this, I use the question related to households' perception of how the standard of living has changed for other households within its community over the course of the previous year. I create a measure of perception of other households' conditions which takes value of one if a household perceives that the standard of living of other households is "worse" and zero if it perceives it remained "same" or got "better". I estimate equation 3 using this binary variable of perceptions about the standard of living of other households as the dependent variable. Despite objective losses among neighbors (as shown in figures 4), it is possible that households are unable to gauge these losses and systematically perceive that the standard of living of other households within its reference group has remained "same" or "got better".

Table 6 provides some support for the potential role of misperceptions in shaping increased

[12]Correspondingly, this increases leave-one-out average poverty in the locality (Fig. A12)

feelings of relative deprivation. Column (1) in Table 6 shows that in the face of a shock, households are actually more likely to report that the standard of living of other households in their community has remained "same" or "got better". This is contrary to what we observe in terms of the effect of the shock on measures of actual losses of other households. Specifically, exposure to positive rainfall deviation, which is above the long-run mean by 2.5 times the long-run standard deviation, reduces the likelihood of reporting other households in their community are "worse-off" by 0.66 percentage points. This suggests that, regardless of how households perceive their *own* losses, they tend to underestimate the effect of shocks on *others* in their communities. This could lead to increased perceptions of relative deprivation. In figure A13 it can be observed that at more severe excess rainfall shocks, households are less likely to report other households have remained "same" or "got better". This suggests that misperceptions about the losses of other households weaken at more severe excess rainfall shock, but it does not reduce in a way that would have an effect on perceived relative deprivation.

Table 6: Effect of Rainfall Shock on Perceptions of Standard of Living of other Households

	Dep. Var.: Perceptions about Other Households
	(1)
Rainfall Shock	-0.660*
Deviation >= 2.5 S.D.	(0.374)
N. of obs.	139,587
N. of Households	44,193
Mean Dep Var	0.116
R2	0.392

Notes: The dependent variable is a binary variable which take value 1 if the household perceives that the standard of living of other households has become "worse" and 0 if it perceives it remained "same" or "got better", in the course of last year. Controls include household head-specific characteristics like sex of respondent (hh head), age, age square, and education level fixed effects. All specifications include household, month of interview, and year fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

6.3 Heterogeneity by Indigenous Households and Human Development Index

Belonging to historically alienated communities or living in regions with lower levels of local development could augment perceptions of relative deprivation. I test this with heterogeneity by indigenous households and the human development index, which is used as a measure of local development.

Indigenous households are those whose household heads' mother tongues are indigenous languages (i.e., Quechua, Aymara, or other native languages). There is evidence related to discrimination against indigenous households in Peru that limits their economic opportunities, even outside the realms of poverty and asset holdings. Alongside evidence of historical discrimination that affects current objective economic outcomes (Dell, 2010), there is evidence of economic discrimination against indigenous households even in current times. Galarza and Yamada (2014) found that indigenous job applicants with similar qualifications to white applicants must send 80% more applications to get a callback chance. They used fictitious resumes with indigenous surnames to apply to actual job vacancies. There is also evidence of indigenous people being exploited through debt bondage, where laborers are trapped in debt they cannot repay through wage advances and other manipulations (International Labor Organization, 2008). In addition, there are other taste-based discrimination against the indigenous people- for example, discrimination based on even *beauty* (Castillo et al., 2010). In summary, these indicate the presence of a persistent pattern of discrimination against the indigenous population in current times. These patterns of discrimination could essentially limit the ability of indigenous households with opportunities to smooth consumption in the face of a shock. There is similar evidence of disparities by race in the ability to smooth consumption in the face of a shock in the U.S.- Black and Hispanic households smooth consumption less than white households in the face of an income shock due to less access to credit, different debt obligations, liquid wealth amongst other factors (Ganong et al., 2020).

Alternatively, I test for heterogeneity using the district-level human development index (HDI). I use the human development index as a measure to capture local development. Low levels of local development can indicate low living standards and fewer economic opportunities, which could also hinder the ability to smooth consumption, shaping perceptions of relative deprivation. Another explanation could be that the salience of deprivation or inequality could be higher within less developed or poorer districts. For example, Fafchamps and Shilpi (2008) shows that isolated communities and households actually care more about relative consumption, contrary to the idea that market interaction fuels invidious comparison. One of the suggested reasons behind this is the salience of inequality- relative differences are more glaring when a homogeneous poor community starts differentiating economically. Relative differences in losses and consumption smoothing in the face of a shock could thus shape perceptions of relative deprivation even within locally less developed or poorer regions. The heterogeneity with respect to the human development index at the district level attempts to capture the effect of the excess rainfall shock on perceived relative deprivation within a region that is less developed.

Table 7 shows the heterogeneity results. I find that indigenous households experiencing an excess rainfall shock are more likely to perceive they are relatively more deprived. Similarly, households inhabiting in districts with lower levels of development captured by the district-level human development index are also more likely to perceive relative deprivation in the face of an excess rainfall shock. This suggests that belonging to historically alienated communities or residing in regions with low levels of development could augment the likelihood of perceived relative deprivation upon experiencing severe excess rainfall shock.

7 Examining the Role of Social Assistance Programs

The results in Section 6.1 suggest that objective losses (e.g., actual household consumption) can partly explain the effect of rainfall shocks on perceived relative deprivation. Importantly, the differential effect of the shock across more vulnerable (poor) *vis-à-vis* less vulnerable (non-poor) households could be an important channel through which excess rainfall shocks affect households' perceptions about relative social positions. If this could explain some of the change in perceived relative deprivation, then government programs that partly offset such losses could mitigate the effect of these shocks on perceived relative deprivation. Therefore, I explore the heterogeneous impact of the excess rainfall shock by access to social programs. Specifically, I test whether access to cash or in-kind assistance can mitigate households' negative perceptions about their relative well-being.

Table 7: Heterogeneity by Indigenous Households and Human Development Index

	Dep. Var.: Perceived Relative Deprivation		
	(1)	(2)	(3)
Rainfall Shock	1.245**	2.435**	2.462**
Deviation >= 2.5 S.D.	(0.506)	(1.021)	(1.161)
× Dummy for Indigenous Household		-1.574	
[=1 if household non-indigenous]		(1.155)	
× Dummy for Districts with HDI ≥ Median HDI			-1.365
[=1 if District HDI ≥ Median HDI in Baseline year-2007]			(1.277)
Effect for non-indigenous HH.		0.860	-
		(0.573)	-
Effect for hhs. in districts			1.097**
with above median HDI			(0.558)
N. of obs.	139,213	139,213	129,626
N. of Households	44,096	44,096	41,748
Mean Dep Var	0.203	0.203	0.205
R2	0.369	0.369	0.375

Notes: Controls include household head-specific characteristics like sex of respondent (hh head), age, age square, and education level fixed effects. All specifications include household, month of interview, and year fixed effects. In column (3), I use baseline HDI for the year 2007; for this purpose, the analytical sample in this case contains households surveyed in rounds 2008-2019. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

7.1 Role of Direct Cash Transfer Program- Juntos

To test whether cash transfer programs have mitigating effects, I focus on the *Programa de Apoyo Directo a los más Pobres - Juntos* (or Direct Support Program for the Poorest – Juntos). This program was launched in April 2005. It provides households with cash transfers to reduce current poverty and prevent intergenerational poverty patterns through increases in human capital investments (i.e., health and education). Through Juntos, eligible poor households receive cash transfers of 200 soles (about US $55) every other month[13], *conditional* on meeting the following conditions: households having children aged 6-14 should attend at least 85% of school days; children aged

[13]Though originally, this program made a monthly transfer of 100 soles to its beneficiaries, later in 2010 this changed to a bimonthly payment of 200 soles.

0-5 should visit healthcare centers for checkups; and finally, pregnant or nursing women must visit healthcare centers for antenatal and postnatal care, respectively. Juntos is the most widely available government-run assistance program for poor households in Peru (Díaz and Saldarriaga, 2019; Morel Berendson and Girón, 2022).

Unfortunately, ENAHO only started recording households' access to social programs (including Juntos) from 2012 onwards. Thus, I test for the role of this program on a limited sample of households (that excludes data before 2012). Since access to government programs (such as direct cash transfers) could be potentially endogenous to excess rainfall shocks (e.g., as a government response to local calamities), I construct an indicator variable for whether households had access to Juntos in the baseline year (i.e., the first year in which a household appears in the panel). Thus, my restricted sample also excludes information from this baseline year.

Column (1) of Table 8 shows the effect of the excess rainfall shock on perceived relative deprivation in the restricted sample of households. Though the effect is still positive, its magnitude is larger than the one found with the full sample (in Table 3). In column (2) of Table 8, I include the interaction of the rainfall shock with an indicator variable that captures access to Juntos at baseline. I find that households without access to Juntos are more likely to perceive relative deprivation in the face of an excess rainfall shock. Specifically, excess rainfall shocks increase households' probability of perceiving relative deprivation by 2.4 percentage points for those without access to this program. In contrast, for households with access to Juntos at baseline, rainfall shocks do not seem to affect their perception of relative deprivation: the effect is small and not statistically different from zero. The difference between non-beneficiaries and beneficiary households is large, but not statistically significant.

7.2 Role of Food Assistance Programs

I also look into the role of in-kind food assistance programs in mitigating perceptions of relative deprivation. Theoretically, access to in-kind assistance also allows for smoothing own consumption losses and thus attenuates the effect of excess rainfall shocks on perceived relative deprivation. Similar to Juntos, I explore the potential heterogeneous impacts of excess rainfall shocks by access

Table 8: Heterogeneous Effect on Perceived Relative Deprivation by Access to Direct Cash Transfer Program in Baseline Year of Survey

	Dep. Var.: Perceived Relative Derpivation	
	(1)	(2)
Rainfall Shock	2.195**	2.393**
Deviation >= 2.5 S.D.	(0.879)	(0.926)
× Baseline Access to Juntos		-1.938
[=1 if household has access in baseline year]		(2.788)
Effect for households with access in baseline year		0.455
		(2.646)
N. of obs.	43,295	43,295
N. of Households	14,660	14,660
Mean Dep Var	0.198	0.198
R2	0.390	0.390

Notes: Since I use the baseline information of access to direct cash transfer program, I leave out the baseline year of the household. Additionally, since the record of social programs was started by ENAHO only in 2012, the analytical sample contains households surveyed in rounds between 2013 and 2019. Controls include household head-specific characteristics like sex of respondent (hh head), age, age square, and education level fixed effects. All specifications include household, month of interview, and year fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

to food assistance programs. Peru has several food assistance programs [14], most targeting to improve mother's and children's nutrition. The ENAHO includes information about access to these programs throughout the entire analysis period (2007-2019). Across all years in the sample, on average, around 35% households had access to different kinds of food assistance programs. Some of the popular assistance programs are Vaso de leche (Glass of Milk), Desayunos o Almuerzos

[14] Popular food assistance programs include- Vaso de leche (Glass of Milk), Comedor popular (incluye club de madres) (Popular dining room), Canasta en Establecimientos de Salud para Niños y Niñas menores de 3 años (Food assistance in health establishments for boys and girls under 3 years of age), Canasta en Establecimientos de Salud para Madres Gestantes (Food assistance in health establishments for pregnant mothers), Canasta en Establecimientos de Salud para Madres que dan de Lactar (Food assistance in health establishments for breastfeeding mothers), Refrigerios o Almuerzos Escolares en Instituciones Educativas de Inicial o PRONOEI (Snacks or school Lunches in initial educational institutions or pre-School initiatives), Desayunos o Almuerzos Escolares en Instituciones Educativas de Primaria (School breakfasts or lunches in primary educational institutions), Atención Alimentaria Wawa Wasi / Cuna Más (Centers for impoverished children aged six to 48 months), INABIF (CEDIF-Centro Comunal Familiar) (Family Community Center)

Escolares en Instituciones Educativas de Primaria, or Qali Warma (School breakfasts or lunches in primary educational institutions). The Vaso de leche program is one of Peru's most active and oldest assistance programs that operates locally and provides milk servings complemented with oats, rice, quinoa flour, or other food items (Zavaleta et al., 2017). The Qali Warma on the other hand is a national school feeding program that aims to provide food service to children above the age of 3 years in public schools. It serves breakfast in some schools, and breakfast and lunch in some- depending on the district poverty rates (Zavaleta et al., 2017). Like the cash transfer program, the idea here is that access to food assistance programs would help the household smooth a part of their consumption in the face of a shock.

Similar to Juntos (Section 7.1), access to food assistance programs could also be endogenous to extreme rainfall shocks (which can create food shortages and foster government aid). I construct a variable that captures whether households have access to *any* food assistance programs listed in the ENAHO in their baseline year (i.e., the first year a household was interviewed in the panel dataset). Therefore, I use a similar sample to the one in Table 3 but exclude observations from households' baseline year. Column (1) of Table 9 shows the baseline effect of the shock on perceived relative deprivation in the restricted sample of households. This effect is slightly larger but overall consistent with the results in Table 3 based on the full sample. In column (2) of Table 9, I add the interaction of the rainfall shock with an indicator variable that captures whether the household had access to any food assistance programs at baseline. I find that households without access to such assistance are more likely to perceive relative deprivation in the face of a shock: excess rainfall shocks increase the likelihood of perceiving relative deprivation by 2.1 percentage points among these households. Alternatively, for households with access to in-kind food assistance at baseline, rainfall shocks do not seem to affect their perception of relative deprivation; the effect is not statistically different from zero. However, the difference in the effect size for households with and without access to in-kind food assistance is not statistically significant.

In summary, the heterogeneous impacts among those with access to cash transfers and in-kind assistance programs suggest that public policies could be critical in attenuating perceptions of relative deprivation in the face of a covariate shock.

Table 9: Heterogeneous Effect on Perceived Relative Deprivation by Access to Food Assistance Program in Baseline Year of Survey

	Dep. Var.: Perceived Relative Deprivation	
	(1)	(2)
Rainfall Shock	1.836***	2.135***
Deviation >= 2.5 S.D.	(0.670)	(0.831)
× Baseline Access to Food Assist. Progs.		-0.832
[=1 if household has access in baseline year]		(1.354)
Effect for households with access in baseline year		1.303
		(1.093)
N. of obs.	78,116	78,116
N. of Households	26,633	26,633
Mean Dep Var	0.201	0.201
R2	0.391	0.391

Notes: Since I use the baseline information of access to food assistance programs, I leave out the baseline year of the household. Controls include household head-specific characteristics like sex of respondent (hh head), age, age square, and education level fixed effects. All specifications include household, month of interview, and year fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

8 Robustness Checks

In this section, I test whether my results are robust to alternate measure of perceived relative deprivation; exposure to emergency events like floods, mudslides, landslides, and heavy rainfall-related emergencies and alternative measures of covariate shocks- like self-reported exposure to natural disasters; changes in sample composition, and endogenous migration and falsification tests with leads (i.e., future) of the rainfall shocks.

8.1 Alternative Measure of Perceived Relative Deprivation

As table 1 shows, in the preferred definition of dependent variable of interest, we have a binary measure of perceived relative deprivation which takes value one *only* when households perceive *strict* relative deprivation. However, this may mask a lot of information and so I construct a categorical variable of perceived relative deprivation with strictly better-off, same as others, and strictly worse-off categories (in that order), as shown in table A1. Following, this I estimate an ordered probit model and report the marginal effects for this regression in table A2. Using this alternate definition we have consistent results, it shows that with exposure to an excess rainfall shock above 2.5 S.D. from the long-run mean significantly increases the probability of perceiving strictly *worse-off* than others in the locality or community, and there is a corresponding decrease in the likelihood of perceiving strictly better-off, as well as, perceiving to be same as others with exposure to an excess rainfall shock of this intensity.

8.2 Exposure to heavy rainfall related emergency events

As discussed earlier, I use excess rainfall shocks to proxy for extreme events like floods, mudslides, landslides, and other heavy rainfall-related emergencies. The National Institute of Civil Defense of Peru provides geographic coordinates (latitude and longitude) of emergency responses by type of emergency events. I match these geographic coordinates with the household locations provided by the ENAHO for a given year, and I categorize a household as exposed to a heavy rainfall-related emergency if it is located within a 500-meter radius from the geographic coordinate of the emergency response provided in the National Civil Defense dataset, and the emergency occurred within the 12 months from the time of interview. The National Institute of Civil Defense of Peru provides emergency response for a wide range of emergency event categories, like- heavy rainfall, floods, mudslides, landslides, storms, fires, droughts, frost/cold waves, hail, earthquakes, epidemics, volcanic eruptions, spillover of harmful substances, environmental pollution and other types of emergencies. I consider only heavy rainfall, floods, mudslides (huaycos), and landslides as these are closely connected to excess rainfall shocks, and so I consider the exposure of households to these types of emergencies only in this case.

Figure A14 shows the locations of huaycos or mudslide-related emergencies in Peru in 2019, alongside the locations of households surveyed in the ENAHO in 2019. Figure A15 shows an illustrative example of the case of the Puacartambo district in Pasco province in Pasco, where the emergency illustrated here is related to a huaycos or mudslide situation that occurred on 21st January 2019. The households located within a radius of 500 meters are considered to be exposed to this emergency as they are in close proximity to this emergency; importantly, these households were interviewed in February 2019 (and the emergency exposure is within the past 12 months from the time of interview) [15]. Alongside huaycos or mudslides, I consider heavy rainfall, floods, and landslide emergencies as documented by the National Institute of Civil Defense of Peru, considering these are most closely related to instances of heavy rainfall.

This also allows us to test if the measure of excess rainfall shock used in this case is a good proxy for exposure emergencies related to heavy rainfall, floods, landslides, and mudslides. Table A3 shows that an excess rainfall shock above 2.5 S.D. from the long-run mean increases the likelihood of being exposed to an *emergency event* related to heavy rainfall, floods, landslides, or mudslides by 3.1 percentage points. This is a large effect size, considering the sample average of the dependent variable; this translates into a 21.3% increase in the probability of exposure to an emergency event related to heavy rainfall, floods, landslides, or mudslides.

Table A4 shows the direct effect of exposure to excess rainfall-related emergency events on perceived relative deprivation. I find that exposure to such emergency events in the past 12 months from the time of the interview increases the likelihood of perceived relative deprivation by 1.06 percentage points. The effect size is quite similar to table 3.

8.3 Alternative Measures: Self-Reported Exposure to Natural Disasters

Next, I check whether exposure to natural disasters (and not just excess rainfall) provides similar consistent findings on perceived relative deprivation. For this, I use self-reported exposure to natural disasters in the past 12 months from the time of the interview (from the governance module of ENAHO).

In Column (1) of Table A5, I reproduce my main results (from Table 3) to ease comparison with estimates using alternative variables to identify similar covariate shocks. Columns (2) and (3) of Table A5 show that exposure to extreme events in the form of natural disasters indeed increases the likelihood of households perceiving their standard of living to be worse off in comparison to other households in the locality. Specifically, conditional of household, year, month of interview

[15] Similar to the rainfall shock, I categorize emergency exposure as a *binary variable* which takes value 1 if the household is located within the 500-meter radius from the location of a relevant emergency and also if it occurs within the past 12 months from the time of interview; and 0 otherwise.

fixed effects and a set of household level controls, self-reported exposure to natural disaster events increases the likelihood of perceiving own household status adversely relative to other households in the locality by 2.58 percentage points. Alternatively, a self-reported measure of exposure to natural disaster events could have endogeneity concerns, so I construct an additional measure of natural disaster indicator, which assigns value 1 to all households within a district only if the majority of the respondents (more than 50% of the respondents within a district) report exposure to natural disasters in the past 12 months from the time of the interview. Using this measure of exposure to natural disasters increases the likelihood of perceived relative deprivation by 1.44 percentage points (column (3) of table A5) [16].

8.4 Changes in Sample Composition and Endogenous Migration

It could be possible that households who experience relatively more excess rainfall shocks could be different from households experiencing relatively lower excess rainfall shocks. Therefore, I test if household characteristics vary systematically by excess rainfall shocks. In table A7, I find that there is no meaningful differences in observable characteristics by exposure to excess rainfall shocks. Additionally, I show that there is no indication of endogenous migration in this case. From 2014 onwards the ENAHO survey data records information on whether 5 years ago the household lived in the same district as during the time of interview. Figure A16 checks whether households are likely to move in response to excess rainfall shocks, possibly to areas with less extreme rainfall shocks. We do not find any evidence suggesting that there is a differential exposure to excess rainfall shocks between households who migrated and those who did not.

8.5 Falsification Exercise

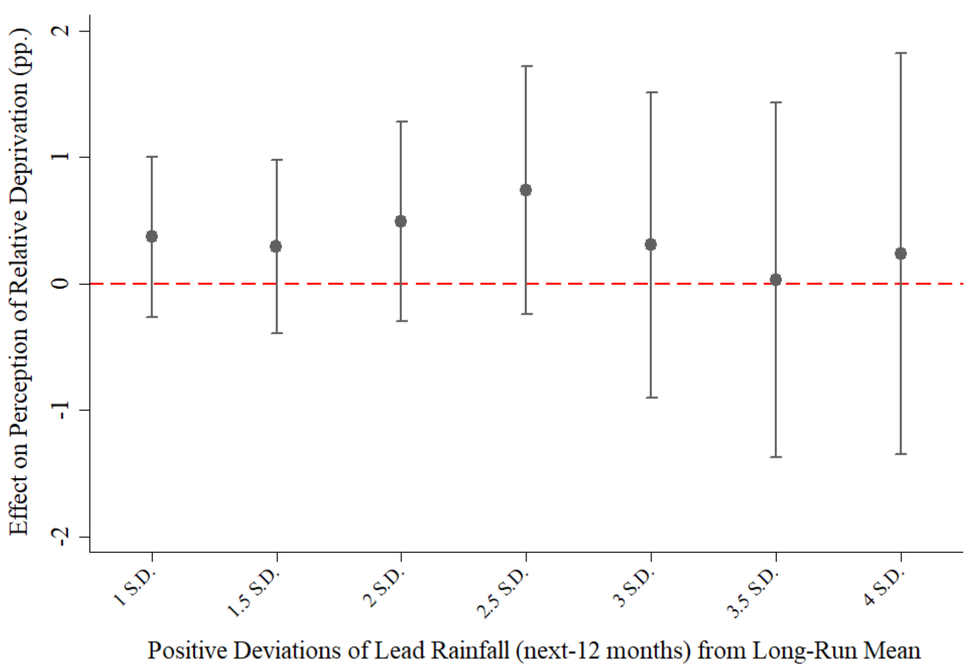
Overall, my identification strategy exploits within-household variation over time, comparing outcomes in years with rainfall shocks relative to periods with relatively average weather patterns.

[16]Table A6 shows the effect of negative rainfall shocks on perceived relative deprivation. I consider deviations below 0.8 S.D. and 1.6 S.D., as these are considered moderate and extreme dry conditions (Tambet and Stopnitzky, 2021; Zhang et al., 2011). The effect of exposure to negative rainfall shock on perceived relative deprivation is similar, even with moderate dry conditions. However, the effect is positive but statistically insignificant for extreme dry conditions, possibly due to only 2% of the sample are exposed to extreme dry shocks.

However, it might still be possible that areas with rainfall shocks would be on differential pre-trends (in terms of perceived relative deprivation) relative to those without such shocks. It could also be that households are able to anticipate (and respond to) future rainfall shocks. Additionally, it is possible that rainfall shocks simply capture unobserved determinants of perceived relative deprivation that vary systematically across households and/or geographic areas.

To rule out these possibilities, I perform a simple falsification test where I estimate the "effect" of *future* excess rainfall shocks. Specifically, I estimate equation 3 where — instead of focusing on exposure to rainfall shocks in the past 12 months to the survey — I use rainfall shocks in the 12 months *after* the interview date. I find that the lead year rainfall shock has no effect on perceived relative deprivation. As shown in Figure 5, all coefficients are small and statistically insignificant. Thus, this suggests that the main estimates do capture the causal effect of extreme rainfall shocks.

Figure 5: Effect of Lead Rainfall Shocks on Perceived Relative Deprivation



No. of observations: 139,587; Households: 44,193; Mean of Perceived Relative Well-Being: 0.20

9 Does Perceived Relative Deprivation Shape Political Attitudes in the Context of Peru?

Recent experimental evidence have established a relationship between perceived relative deprivation and political attitudes (Kosec and Mo, 2021). As noted earlier, alongside shaping political attitudes, perceived relative deprivation also shapes other important outcomes like physical and mental health, hostile and aggressive behavior, subjective well-being or life satisfaction, and support for redistribution.

In this section, I draw a relationship between perceived relative deprivation and political trust, specifically, belief in the functioning of democracy and preference for democratic vis-à-vis autocratic regimes. The measure of belief in the functioning of democracy is most closely related to a widely used measure-"satisfaction of democracy," which is used as a summary measure of political trust or confidence in government institutions (Citrin and Stoker, 2018; Norris, 2011). This measure most likely captures both "diffuse" attitudes towards the political system (i.e., democracy as a principle or as a broad institution) and "specific" satisfaction with or confidence in the current or recent government regimes (i.e., how democracy works in practice and citizens' evaluation of the performance of different government bodies and different levels of the government- central, regional, provincial, and district level). Studying the effects of perceived relative deprivation on political trust can have important policy relevance as political trust and confidence in government institutions shape policy preferences, compliance with laws, political participation and voting behavior, and the use of public goods and services (Fairbrother, 2019; Citrin and Stoker, 2018; Bélanger, 2017; Christensen et al., 2021; León-Ciliotta et al., 2022).

ENAHO collects political beliefs and confidence in public institutions in the first part of the governance module which could be responded by an randomly chosen adult individual within the household. The two key measures of political attitudes are discussed in more detail as follows. Firstly, whether households believe "democracy functions well in Peru?" I code the responses to this question as one to those who believe democracy works "well" or "very well" and zero otherwise (see below). This measure is widely considered to be a summary measure of political trust.

$$Y_{idt} = \begin{cases} 1 & \text{if response is "very well" or "well"} \\ 0 & \text{if response is "very poorly" or "poorly"} \end{cases} \tag{7}$$

I also examine the relation between perceived relative deprivation and preference for authoritarian regimes over democratic regimes. For this, I use the question asked in the governance module- "With which of the following opinions do you agree- a) A democratic government is always preferable; b) In some circumstances, authoritarian government is preferable to a democratic one, and c) I don't care if it is an authoritarian or democratic government"

$$Y_{idt} = \begin{cases} 1 & \text{if response is (a) or (c)} \\ 0 & \text{if response is (b)} \end{cases} \tag{8}$$

I estimate the following equation: the dependent variable is these two measures of political trust, and the main variable of interest is perceived relative deprivation. I control for α_i, γ_t and θ_m capturing household, year and month of interview fixed effects respectively [17]. Standard errors are clustered at the household level.

$$Y_{idmt} = \beta_1 PerceivedRel.deprivation_{idmt} + \alpha_i + \gamma_t + \theta_m + \varepsilon_{idmt} \tag{9}$$

Exploiting within-household variation in perceived relative deprivation, I find that households that perceive relative deprivation are more likely to report democracy functions "poorly" or "very poorly" in Peru; additionally, these households are also more likely to prefer "authoritarian regimes over democratic ones, in some circumstances". Specifically, perceived relative deprivation increases the likelihood of perceiving democracy functions "poorly" or "very poorly" by 1.15 percentage points and expressing support for autocratic regimes over democratic ones, in some circumstances, by 0.79 percentage points (table 10). Considering the sample average, these translate to a 2.1%

[17] Since the political beliefs could be reported by any adult individual within the household (and not just household head), I do not control for respondent specific characteristics in this case, as these are most likely captured by household fixed effects. In table A8 , I restrict the sample where both perceived relative deprivation and the political perception are responded by the household head. The results are quite similar. In column (3) of table A8, we drop the "don't know" responses in constructing preference for Democracy v/s Autocratic Regime variable, and the results hold.

Table 10: Association between Perceived Relative Deprivation and Belief that Democracy Functions Well in Peru & Preference between Authoritarian v/s Democratic Regimes

	Democracy Functions Well (1)	Authoritarian v/s Democracy Preference (2)
Perceived Relative Deprivation	-1.146***	-0.785**
	(0.415)	(0.315)
N. of obs.	112,422	113,049
N. of Households	37,275	37,458
Mean Dep Var	0.432	0.858
R2	0.459	0.397

Notes: All specifications include household, month of interview and year fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

and 5.5% increase in negative perception related to the working of democracy and preference for democratic regime, respectively. Overall, these results provide evidence that perceived relative deprivation matters for determining political attitudes that could be key in the Peruvian context.

10 Conclusion

This paper provides important evidence on the effects of covariate shocks- in the form of excess rainfall shocks on perceptions of relative deprivation. I find that exposure to excess rainfall shocks in the past year (from the time of interview of the household) can bring about large changes in perceptions of relative deprivation. This is potentially explained by the differential effect of excess rainfall shocks on objective welfare outcomes across the poor and the non-poor households. Further, I find that this differential effect translates into an increase in actual relative deprivation, as measured by the Stark or Yitzhaki measures of relative deprivation. Additionally, I show that this could also be guided by misperceptions about the losses of other households within a locality.

This study also explores the role of social protection programs in weakening the effect of heavy rainfall shocks on perceived relative deprivation. I find that both direct cash transfers and in-kind transfers can possibly play an important role in attenuating the effect of excess rainfall shocks on perceived relative deprivation. This is an important contribution to literature related to the role of redistributory policies in mitigating perceived relative deprivation.

Overall, this study makes novel contributions through these findings, especially given that it is in a developing country context with a non-experimental, real-world setting. A key takeaway is that subjective perceptions about relative economic position could be different from objective economic losses. The findings could also generate potential interest amongst the literature linking changes in income levels with political attitudes, instability and conflict, by identifying that changes in levels of income may not be the only channel through which weather shocks could affect these outcomes and there could be alternate channels like changes in perceived relative deprivation.

11 Appendix: Figures and Tables

Figure A1: Weather Related Emergency Responses in Peru

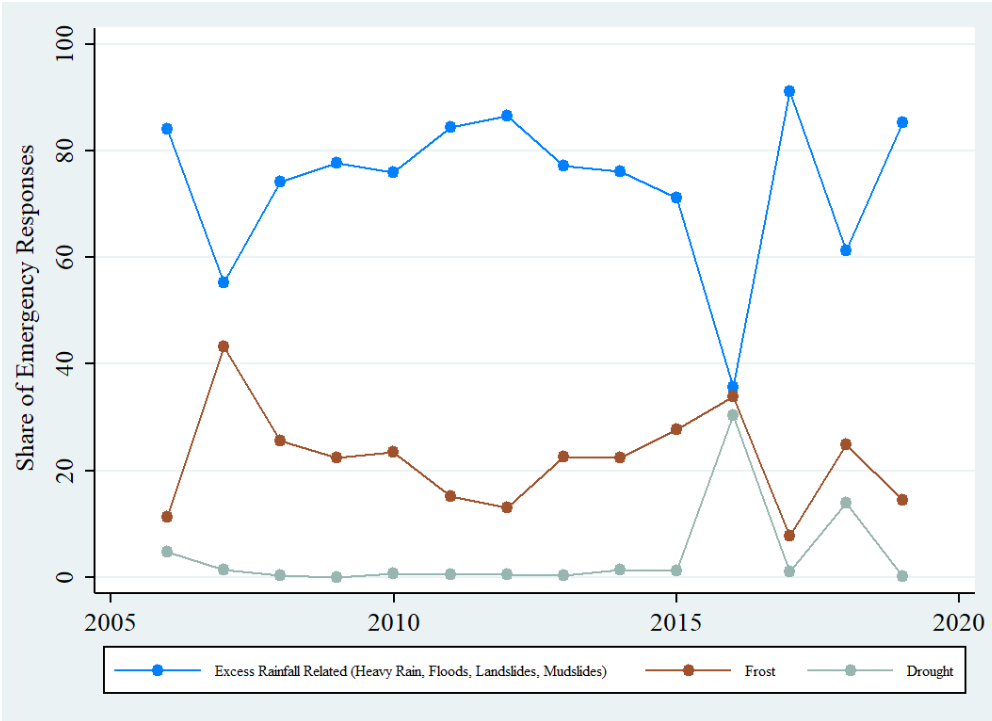
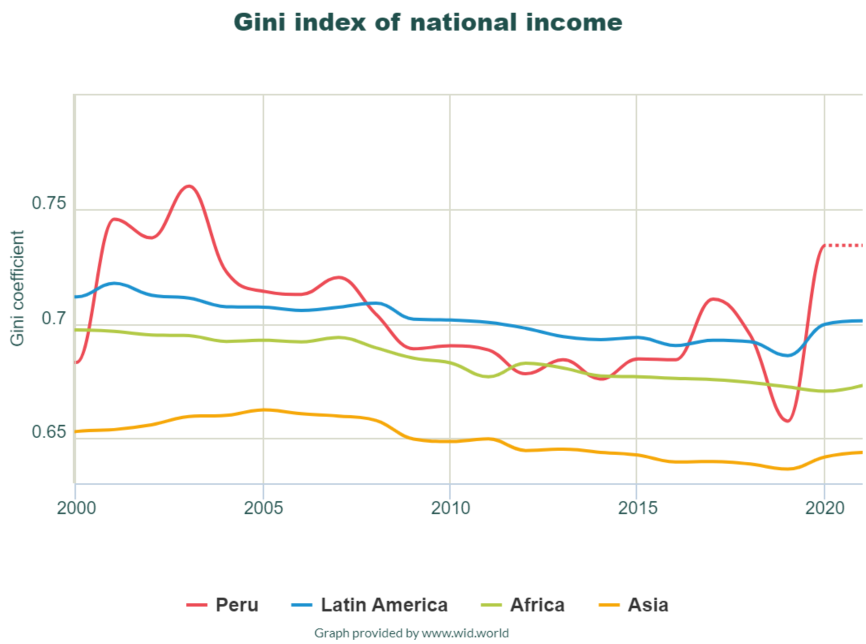
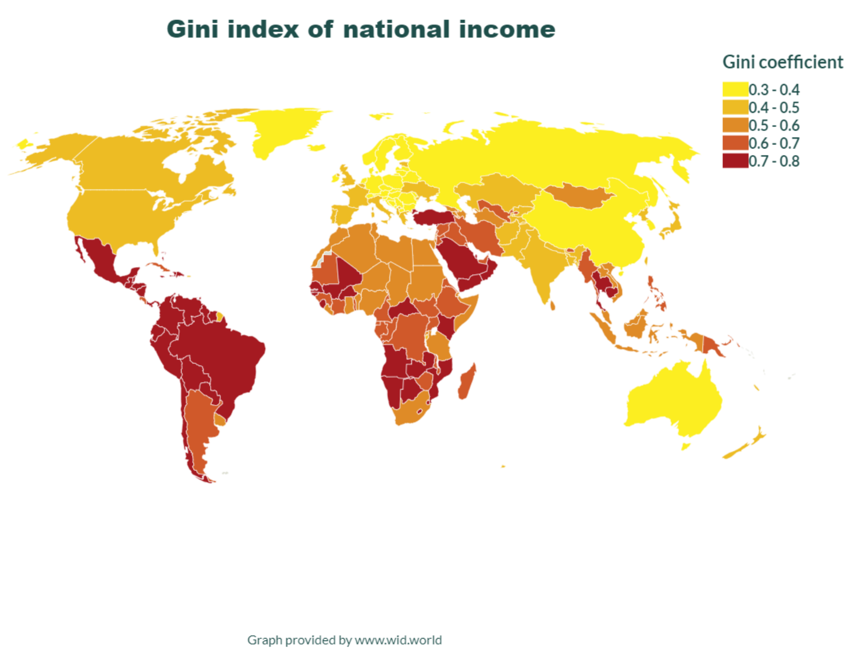


Figure A2: Income Inequality in Peru, Latin America, Africa, and Asia



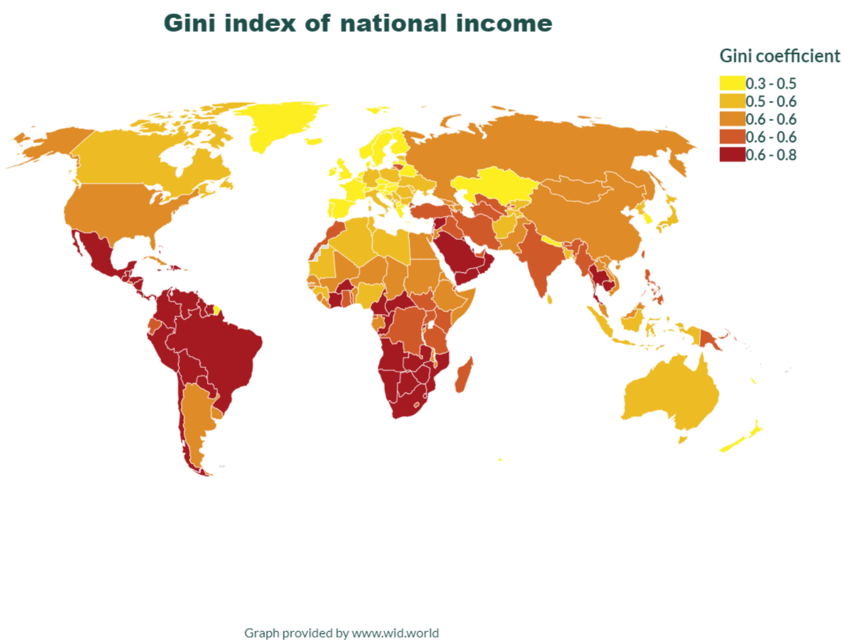
Source: World Inequality Database

Figure A3: Income Inequality by Countries, 1990



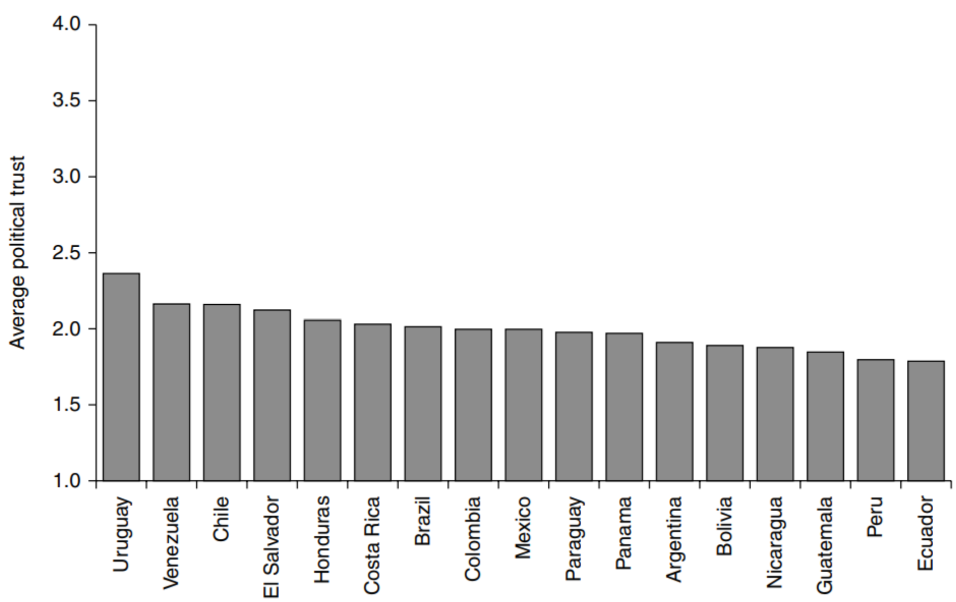
Source: World Inequality Database

Figure A4: Income Inequality by Countries, Latest Year



Source: World Inequality Database

Figure A5: Trust in political institutions by country in Latin America (average, 1996-2011)



Source: Bargsted et al. (2017) , Handbook of Political Trust. The index is an average of trust in three political institutions: the national congress, political parties, and the government.

Figure A6: Location of households used in the analytical sample

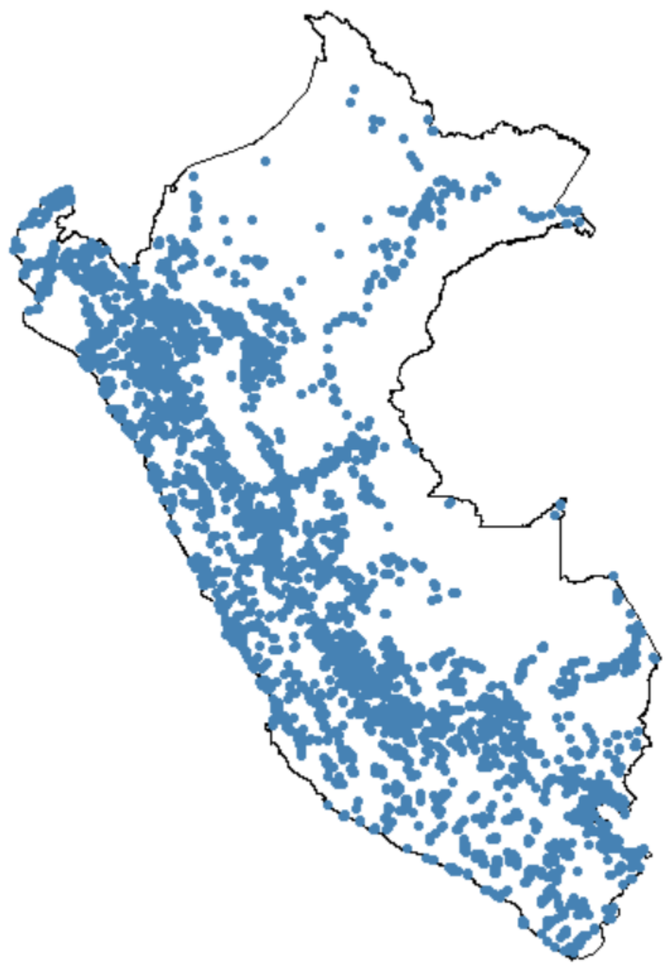


Figure A7: Effect on Poverty

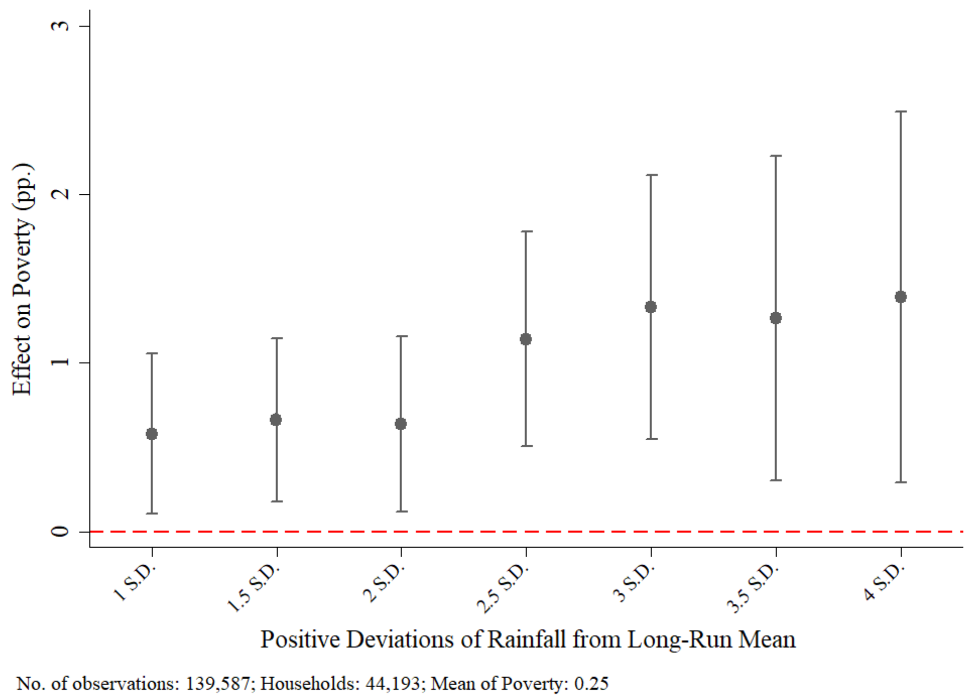


Figure A8: Differential Effect on Household Per Capita Expenditure

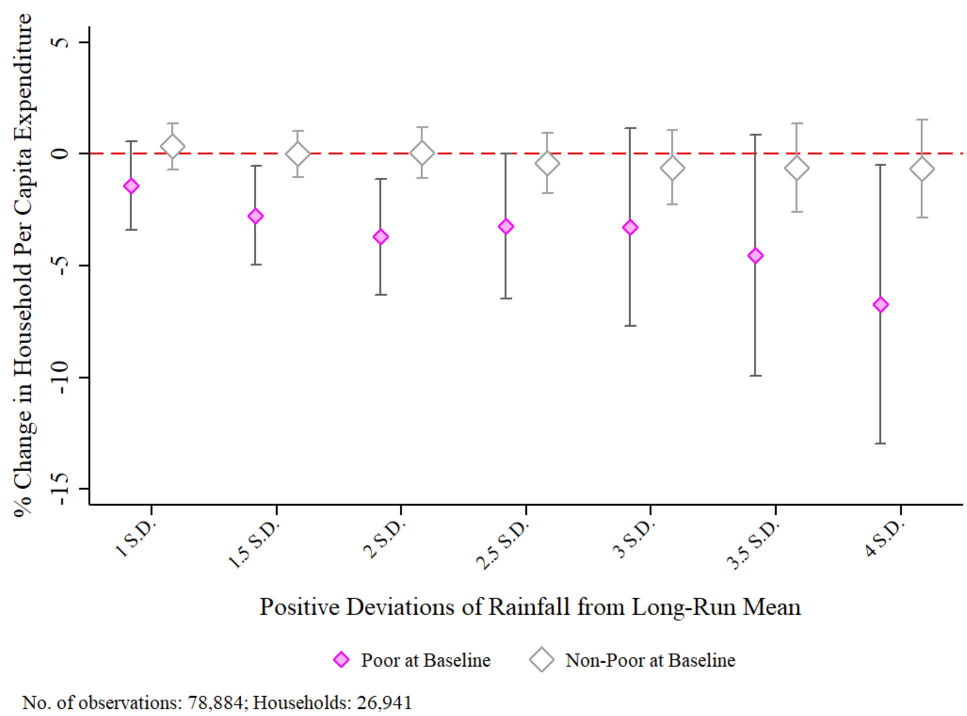
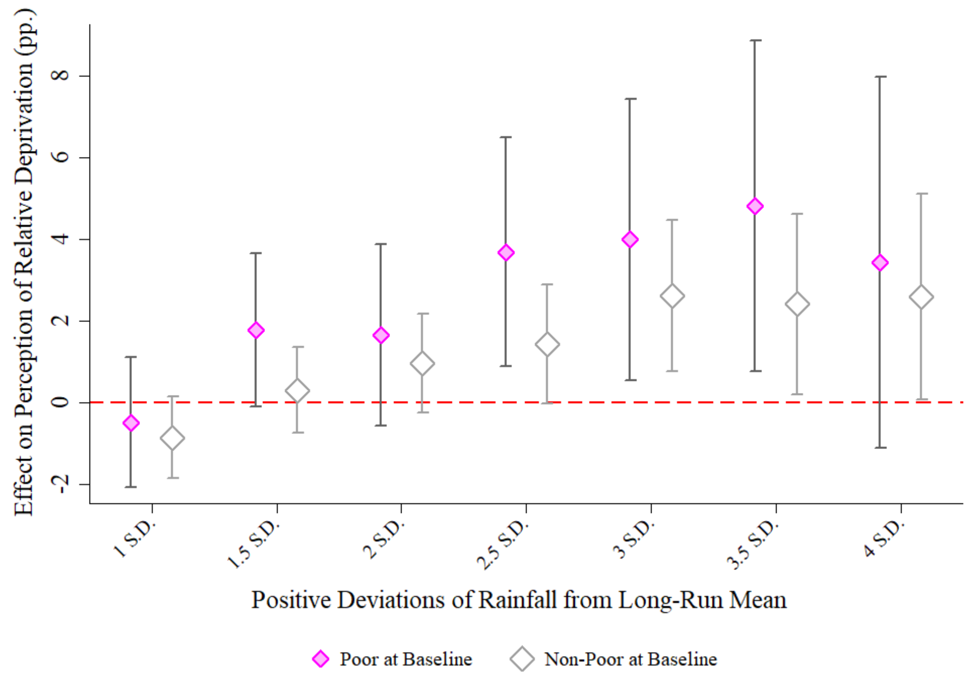
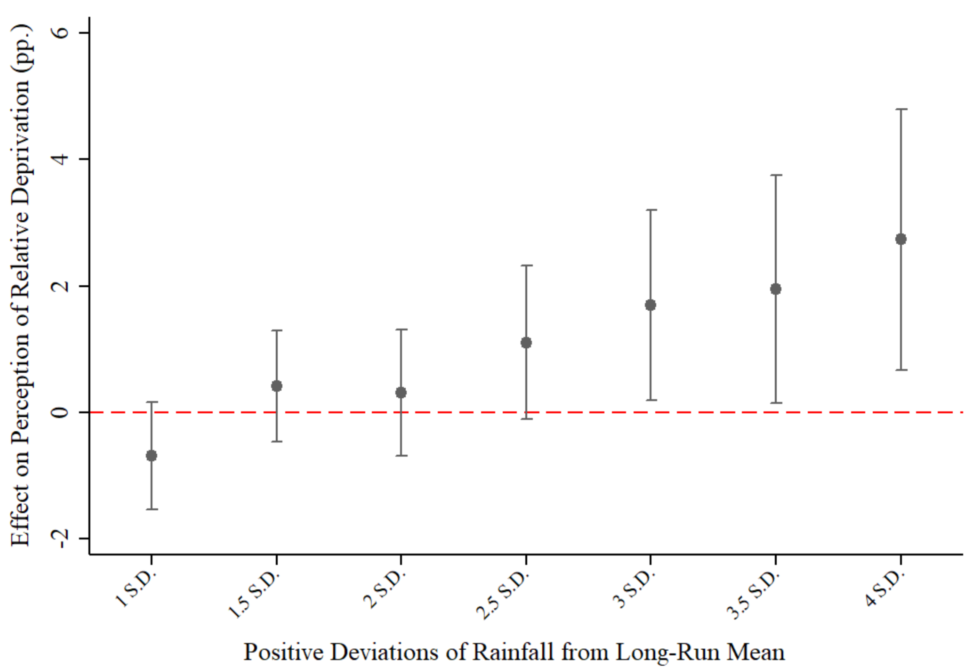


Figure A9: Differential Effect of Perceived Relative Deprivation



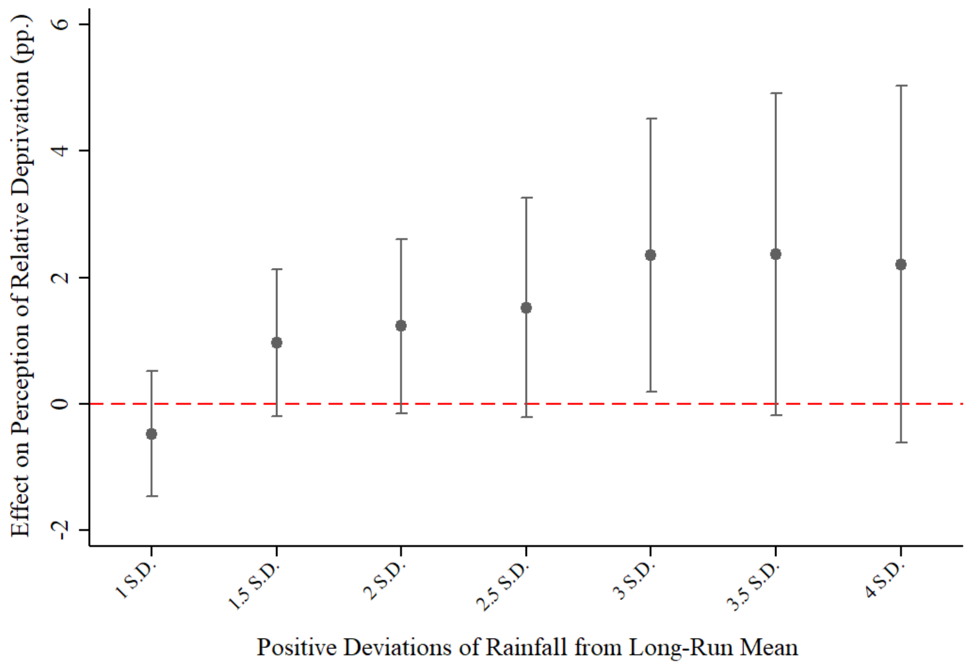
No. of observations: 78,884; Households: 26,941

Figure A10: Effect of Perceived Relative Deprivation (On Sub-Sample of Always Non-Poor)



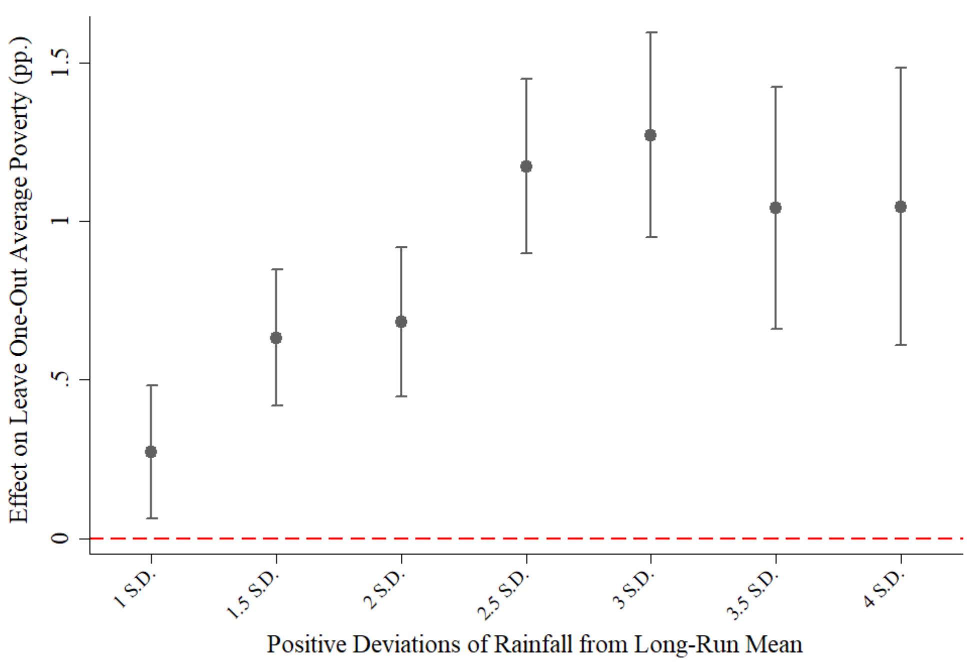
No. of observations: 81,635; Households: 26,658 ; Mean of Perceived Relative Deprivation: 0.21

Figure A11: Effect of Perceived Relative Deprivation (On Sub-Sample of Always Poor + Switchers/Atleast once Poor)



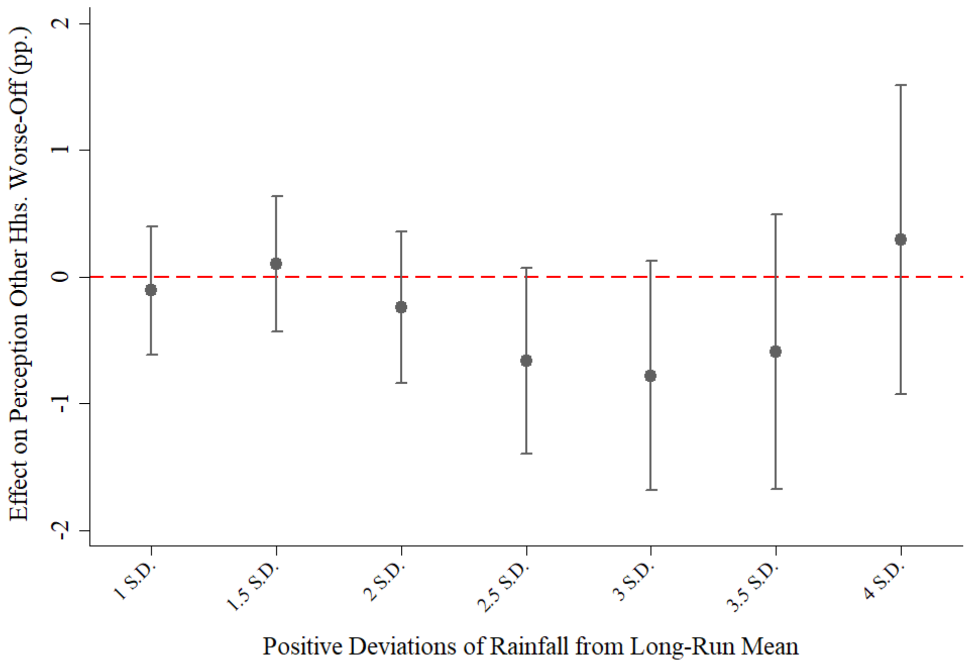
No. of observations: 57,952; Households: 17,535 ; Mean of Perceived Relative Deprivation: 0.19

Figure A12: Effect on Leave-one-out Average Poverty



No. of observations: 138,590; Households: 43,745; Mean of Leave One-Out Average Poverty: 0.25

Figure A13: Effect on Perceptions of Other Households being Worse-Off



No. of observations: 139,587; Households: 44,193; Mean of Perceiving Other Hhs. Worse-Off: 0.12

Table A1: Perceived Relative Deprivation (Alternate Measure)

Perception of Relative Deprivation		In the course of the last year, the standard of living of households in your locality or community: got better	same	worse
In the course of last year, the standard of living of your household?	got better	same (=2)	hh perception-better off (=1)	hh perception-better off (=1)
	same	*hh perception-worse off (=3)*	same (=2)	hh perception-better off (=1)
	got worse	*hh perception-worse off (=3)*	*hh perception worse off (=3)*	same (=2)

Table A2: Ordered Probit Model (Marginal Effects)

	Better-Off than others (=1)	Same as others (=2)	Worse-Off than others (=3)
Rainfall Shock	-0.786***	-0.277***	1.063***
Deviation $\geq$ 2.5 S.D.	(0.306)	(0.108)	(0.414)
N. of obs.	139,587	139,587	139,587
N. of Households	44,193	44,193	44,193
Mean Dep Var	0.1279	0.6688	0.2032

Notes: Dependent variable is a categorical variable and takes 3 distinct values: 1 for strictly better-off, 2 for same as others and 3 for strictly worse-off. Controls include household head specific characteristics like sex of respondent (hh head), age, age square, education level fixed effects. All specifications include household, month of interview, and year fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

Figure A14: Location of households surveyed in 2019 and all Huaycos-related emergencies in 2019

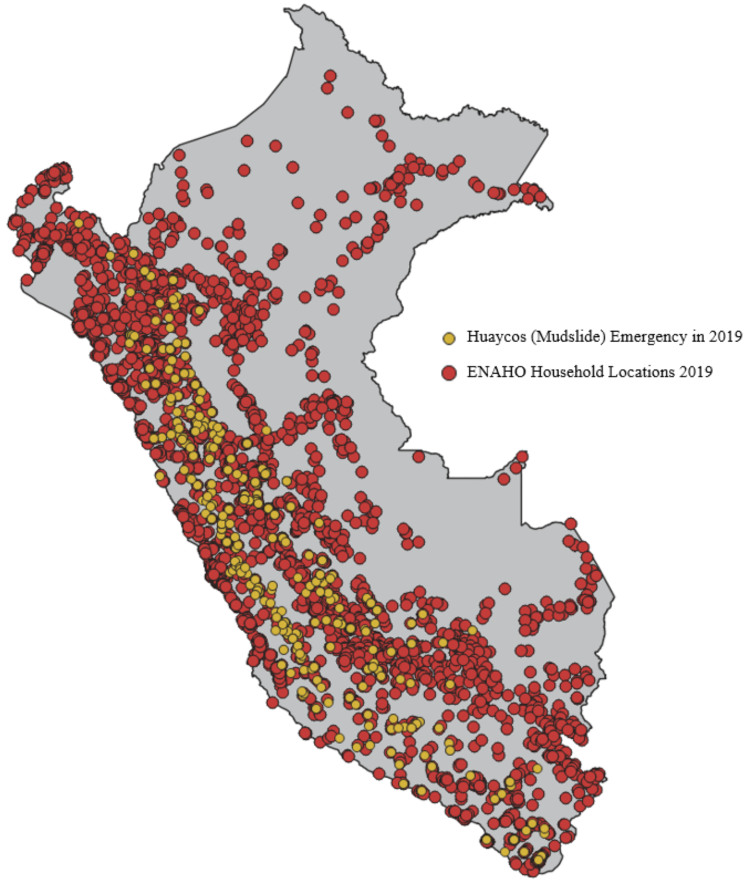
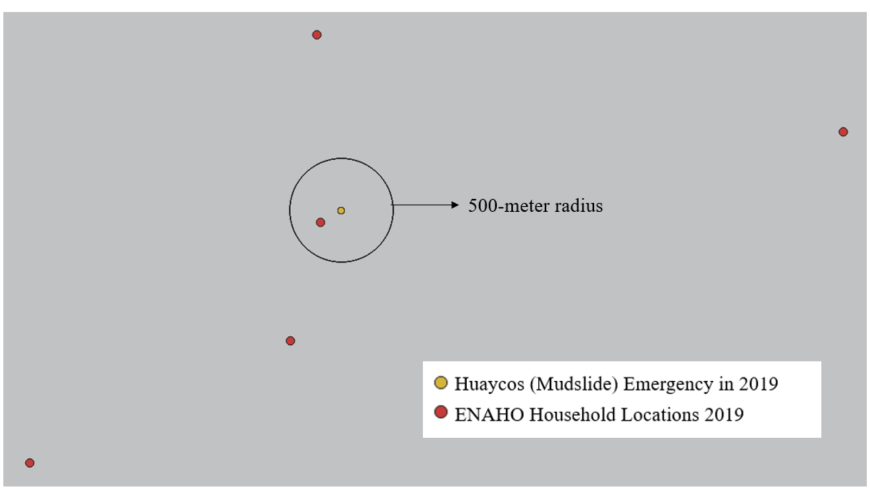


Figure A15: Illustrative example of households exposed to mudslides in Puacartambo District in Pasco Province, Pasco in 2019



The households with a location within the 500-meter radius are considered to be exposed to a mudslide emergency. The locations outside the radius are not considered to be exposed.

Table A3: Effect of Rainfall Shock on Exposure to Emergency Events

	Dep. Var.: Exposure to Emergencies
	(1)
Rainfall Shock	3.094***
Deviation >= 2.5 S.D.	(0.351)
N. of obs.	139,587
N. of Households	44,193
Mean Dep Var	0.145
R2	0.613

Notes: The dependent variable is a binary variable that takes value 1 if the households are located within a 500-meter radius of heavy rainfall, flood, landslide, or mudslide-related emergency in the past 12 months from the time of interview and 0 otherwise. I control for household, month of interview, and year fixed effects in this specification. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A4: Effect of Exposure to Emergency Events on Perceived Relative Deprivation

	Dep. Var.: Perceived Relative Deprivation
	(1)
Exposure to Emergencies	1.059**
heavy rainfall, floods, landslides, mudslides	(0.471)
N. of obs.	139,587
N. of Households	44,193
Mean Dep Var	0.203
R2	0.368

Notes: The explanatory variable of interest is a binary variable that takes value 1 if the households are located within a 500-meter radius of heavy rainfall, flood, landslide, or mudslide-related emergency in the past 12 months from the time of interview and 0 otherwise. Controls include household head-specific characteristics like sex of respondent (hh head), age, age square, and education level fixed effects. All specifications include household, month of interview, and year fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A5: Effect on Perceived Relative Deprivation

	Dep. Var.: Perceived Relative Deprivation		
	(1)	(2)	(3)
Rainfall Shock	1.249**		
Deviation >= 2.5 S.D.	(0.505)		
Self-Reported Natural Disaster		2.583***	
		(0.481)	
Natural Disaster Indicator			1.436**
=1 if >= 50% of hhs. reported exposure to a natural disaster in a district			(0.660)
N. of obs.	139,587	139,582	139,587
N. of Households	44,193	44,192	44,193
Mean Dep Var	0.203	0.203	0.203
R2	0.368	0.368	0.368

Notes: Notes: Controls include household head specific characteristics like sex of respondent (hh head), age, age square, education level fixed effects. All specifications include household, month of interview, and year fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

Table A6: Effect of Negative Rainfall Shock on Perceived Relative Deprivation

	Perceived Relative Deprivation	
	(1)	(2)
Rainfall Shock	1.054**	
Deviation $\leq$ 0.8 S.D.	(0.484)	
Rainfall Shock		0.697
Deviation $\leq$ 1.6 S.D.		(0.923)
N. of obs.	139,587	139,587
N. of Households	44,193	44,193
Mean Dep Var	0.203	0.203
R2	0.368	0.368

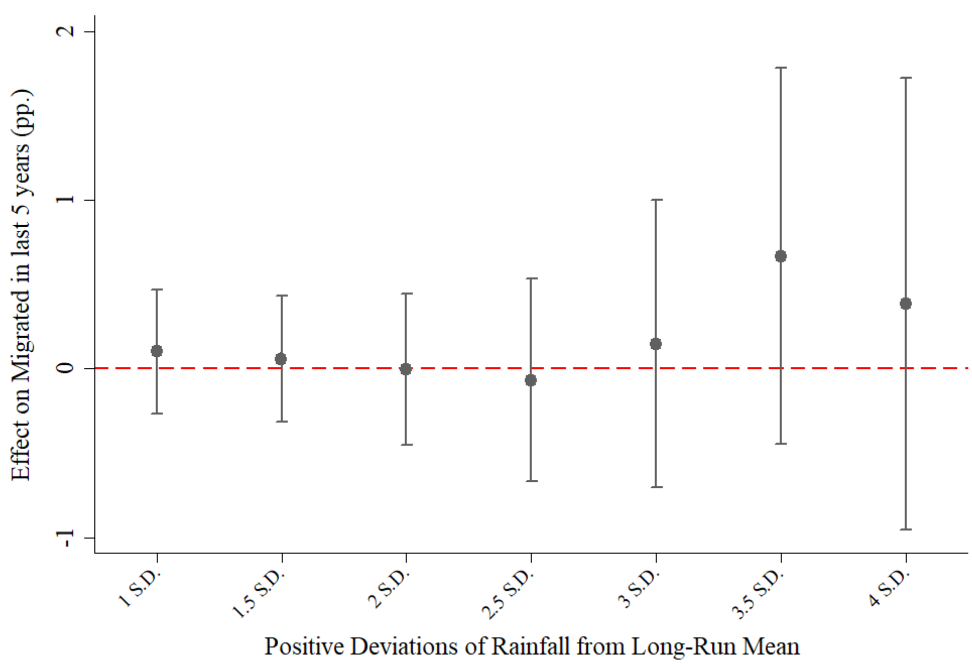
Notes: Controls include household head-specific characteristics like sex of respondent (hh head), age, age square, and education level fixed effects. All specifications include household, month of interview, and year fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

Table A7: Excess Rainfall Shock and Sample Composition

	Male	Age	Primary Education
Rainfall Shock	-0.0065	-0.0017	-0.0010
Deviation $\geq$ *2.5 S.D.*	(0.0046)	(0.0738)	(0.0019)
N. of obs.	139,587	139,587	139,587
N. of Households	44,193	44,193	44,193
Mean Dep Var	0.490	50.864	0.095

Notes: Except when used as an outcome, controls include household head specific characteristics like sex of respondent (hh head), age, age square, education level fixed effects. All specifications include household, month of interview, and year fixed effects. Standard errors clustered at the household level *** p<0.01, ** p<0.05, * p<0.1.

Figure A16: Endogenous Migration



No. of observations: 70,459 ; Households: 23,744; Mean of Migrated in last 5 years: 0.04

Table A8: Perceived Relative Deprivation and Political Attitudes

	Democracy Functions Well (1)	Democracy v/s Authoritarian Preference (2)	Democracy v/s Authoritarian Preference (3)
Perceived Relative Deprivation	-1.298**	-0.878**	-0.993***
	(0.576)	(0.435)	(0.383)
N. of obs.	59,085	59,409	88,109
N. of Households	21,802	21,927	30,977
Mean Dep Var	0.423	0.862	0.832

Notes: Restricted sample in Column (1) and (2)- respondent for perceived relative deprivation and political perception are same (hh. head). Column (3) does not consider "don't care" option in constructing preference for Democracy v/s Autocratic Regime variable. Controlling for household, year, and month of interview fixed effects. All coefficients and standard errors (in parentheses) have been multiplied by 100 for easy interpretation.

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