**The joint effects of monsoon rainfall anomalies and natural disasters on food security: A natural experiment using the 2015 Nepal earthquake**

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Paper Submitted for
2019 Annual Meeting of the Population Association of America

**Abstract:**
Climate change is associated with a greater frequency of extreme weather events. Exposure to such extreme events may leave affected populations with less time to recover from an environmental shock before being impacted by a subsequent event. In this paper, we ask how exposure to an earthquake followed by monsoon rainfall anomalies impacts household food security in Nepal. We link data from the 2016 Nepal Demographic and Health Survey to district-level data on severity of exposure to the 2015 Nepali earthquake as well as rainfall anomalies during the 2015 monsoon season. We exploit regional variation in exposure to the earthquake and rainfall anomalies to isolate the independent and joint effects of each set of conditions. Further, we examine how these relationships are mediated by urban/rural status. We find that among households in areas not severely impacted by the earthquake, greater monsoon rainfall is negatively associated with moderate to severe food insecurity, and this relationship is stronger among rural populations. In contrast, among households in areas that were heavily damaged by the earthquake, greater rainfall is positively associated with food insecurity, likely due to the increased risk of landslides. In light of increases in the frequency of extreme events and natural disasters, this paper helps to identify how joint exposure to multiple shocks impacts food security. The findings can in turn inform adaptation strategies to improve health and well-being in the face of climate change.

## Introduction

Food insecurity is a critical population health challenge. While progress has been made in alleviating hunger over the past several decades, there has been an uptick in food insecurity during in recent years, and 10% of the global population currently experiences severe food insecurity (FAO et al. 2018). Food insecurity acts as a key barrier to socioeconomic development, and as such, the United Nations has aimed one of its Sustainable Development Goals (SDGs) at ending global hunger and ensuring year round access to safe, nutritious, and sufficient food by 2030 (United Nations 2015). Yet climate change may undermine this goal. Climate change is associated with higher temperatures, changing precipitation patterns, and an increased frequency and severity of extreme weather events such as floods, droughts, and heat waves. This poses significant threats to global food security for both rural and urban populations by impacting agricultural production, food prices, and food system infrastructure (Lesk, Rowhani, and Ramankutty 2016; Porter et al. 2014; Wheeler and von Braun 2013). Indeed, Springmann et al. (2016) estimate that climate change will lead to a 3.2% decline in per-capita food availability by 2050.

As adverse weather conditions increase in frequency (AghaKouchak et al. 2018), populations will have less time to recover from an environmental shock before being impacted by a subsequent event. For example, in Ethiopia, in 2016 a severe drought was followed by widespread flooding, which killed livestock and displaced already drought-stricken households (FAO 2016b). Further, in 2018, Japan experienced its worst flooding in decades closely followed by record-breaking heat waves (Gronewald 2018). Studies have examined how natural disasters and adverse climatic conditions impact crop production and food security (e.g., Lesk et al. 2016), yet little is known about the extent to which exposure to multiple environmental shocks in close succession compounds these relationships.

In this paper, we focus on Nepal, a country that is acutely vulnerable to the impacts of climate change on food security. Twenty-five percent of the population lives in poverty, over 50% of Nepali households experience food insecurity, and 36% of children aged 6-59 months are chronically malnourished (Asian Development Bank 2018; Ministry of Health Nepal, New ERA, and ICF 2017; World Food Programme 2018). Further, two-thirds of Nepalis are employed in agriculture, the majority of which is rain fed (FAO 2018). Food production in Nepal is highly dependent on the timing of monsoon onset as well as rainfall amounts, and flooding and landslides are common during periods of heavy rainfall. Climate projections for South Asia predict an increase in both above- and below-normal monsoon rainfall, a greater frequency of extreme precipitation events, and an increase in extreme heat conditions during the summer (World Bank 2013). As a result of climate change, by 2030 Nepal is predicted to experience declines in the production of rice, wheat, and cereal grains, as well as a 5% reduction in real GDP, given the central role that agriculture plays in the country's economy (Bandara and Cai 2014).

In April 2015, Nepal was hit by a severe earthquake that affected nearly half of the country's 75 districts, 14 of which were impacted severely (WHO 2015). We use this event as a natural experiment to understand the extent to which exposure to a natural disaster may magnify the effects of subsequent monsoon rainfall conditions on household food security. We investigate how severity of the earthquake at the district level as well as 2015 monsoon rainfall conditions independently and jointly affect food security among households in 2016. We predict that exposure to the earthquake will magnify the negative effects of adverse rainfall conditions on food security, as households who experience a severe environmental stressor are less able to cope with a subsequent stressor. This paper helps to identify how exposure to multiple environmental stressors impacts household food security, which can in turn inform policies to improve health and well-being in the face of climate change.

## Food Security, Climate, and Natural Disasters

Food security is defined as "all people at all times, hav[ing] physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit 1996). To achieve food security there must therefore be adequate and stable food production, the ability for all individuals to access food, and the capacity for individuals to benefit from the nutrients contained within food. Climate variability as well as extreme weather events have been linked to recent increases in global food insecurity through their effects on each of these components (FAO et al. 2018).

Droughts in particular have a large impact on food availability, leading to more than 80% of the losses in crop and livestock production (FAO et al. 2018). Reduced production is linked to income shortfalls and increased food prices, which limit food access among affected populations. In addition, floods and natural disasters can impact food security through damages to agricultural land and assets; destruction of food storage infrastructure, roads, and transport networks; and transmission of waterborne diseases that limit the ability to absorb nutrients from food (Vermeulen, Campbell, and Ingram 2012; Wheeler and von Braun 2013).

Climate change is expected to increase the frequency, duration, and severity of extreme weather events including droughts, floods, and tropical cyclones. Populations exposed to such extreme events may be particularly vulnerable to subsequent shocks as they might not have enough time to recover from the first shock in terms of health, income, assets, and livelihoods. While empirical evidence on the impacts of environmental stressors on food security is growing, there is limited understanding of how multiple stressors experienced in short succession interact to affect food security.

## The 2015 Nepal Earthquake and Monsoon

On April 25, 2015, a 7.8 magnitude earthquake struck the Gorka District of central Nepal, followed by more than 250 aftershocks greater than 3.0 in magnitude over the subsequent weeks (Kargel et al. 2016). The earthquake and aftershocks led to 4,000 landslides, caused approximately 9,000 deaths and 23,000 injuries, destroyed over half a million homes, and displaced two million people (Basnyat et al. 2015; Government of Nepal National Planning Commission 2015; Kargel et al. 2016). Thirty-one of Nepal's 75 districts were affected, with 14 districts facing the most severe impacts (see Severely and Crisis Hit districts in Figure 1). Kathmandu, Nepal's capital city, was among the crisis hit areas, though poor rural areas were most adversely affected due to inferior housing construction (Government of Nepal National Planning Commission 2015).

The earthquake threatened food production and access in the worst affected districts, as households lost stored grain and seeds, cattle were killed, and roads and markets were destroyed (Webb, West, and O'Hara 2015). The humanitarian response to the earthquake was rapid, as numerous countries, international organizations, and NGOs donated services, money, equipment, and food to help with recovery. For example, in the six weeks following the earthquake the United Nations World Food Programme provided food assistance to two million people in the 14 most affected districts and worked to rebuild irrigation systems and repair roads (United Nations 2016). In addition, the FAO aided 1.5 million people in the six most affected districts by providing seeds and grain storage bags, repairing livestock shelters, and rehabilitating irrigation schemes (FAO 2016a).

The earthquake occurred shortly before the onset of the monsoon season, which typically extends from early June through late September. Nepal receives about 80% of its annual rainfall during this time, with heavy rainfall events leading to flooding and landslides and low rainfall reducing crop and livestock production. During the 2015 monsoon season, Nepal received about 25% less rainfall than average, with the most severe drought conditions occurring in the center-west regions (World Meteorological Organization 2016). Most areas of the country experienced drier-than-average conditions, which decreased agricultural production and increased food prices (Ministry of Agricultural Development, FAO, and WFP 2016). In addition to the thousands of landslides resulting from the earthquake, the 2015 monsoon rains triggered a number of additional landslides. Despite the weaker-than-normal monsoon, rains led to landslides at rates 10-20 times that of a normal monsoon season, with the landslides concentrated in the areas hardest hit by the earthquake (Rosser, Densmore, and Oven 2016).

## Methods

### *Data*

We link data from the 2016 Nepal Demographic and Health Survey (DHS) to district-level data on severity of exposure to the 2015 earthquake as well as high-resolution rainfall data. The Nepal DHS is representative at the national, province, and rural/urban levels, and uses a clustered sampling design. The sample was stratified by province and well as rural/urban status, and subsequently 383 enumeration areas (clusters) were selected, with 30 households interviewed in each cluster. Households were given a questionnaire, and women aged 15 and 49 completed an additional questionnaire. Data were collected between June 2016 and January 2017 from 11,040 households in 73 of Nepal's 75 districts (Ministry of Health Nepal et al. 2017). The DHS data contain information on food security as well as geographic coordinates of the location of the sampling clusters, length of time in residence among surveyed women, and an array of household- and community-level control variables. Our analytic sample consists of 11,029 households with non-missing values on variables of interest.

We create a measure of household food security based on the Household Food Insecurity Access Scale (HFIAS) (Coates, Swindale, and Bilinsky 2007) and following the technique used by the Nepal DHS (DHS Program 2014). Heads of household were asked a set of nine questions that addressed how often during the prior 12 months they or any members of their household: worried about not having enough food, were unable to eat preferred foods, ate smaller meals, ate fewer meals, lacked food to eat, went to sleep hungry, or had to go an entire day and night without eating. Based on the responses, households were classified into four categories: food secure, mildly food insecure, moderately food insecure, and severely food insecure. Among the analytic sample, 47% of households were food secure, 21% were mildly food insecure, 22% were moderately food insecure, and 10% were severely food insecure.

We include a measure of earthquake damage at the district level (Government of Nepal National Planning Commission 2015). The top map in Figure 1 displays the six categories of district-level earthquake damage as well as the locations of the DHS clusters. Thirty-one districts were affected by the earthquake, with 14 districts experiencing the most severe impacts in terms of deaths, injuries, and damage to infrastructure. These districts are classified as severely hit and crisis hit on the map, and we hereby refer to them collectively as "severely affected". Among the analytic sample, 23% of households lived in the severely-affected districts.

To understand the effects of rainfall anomaly, we use data on daily total precipitation from the Climate-Weather Research and Forecasting Model (CWRF) developed by the Earth System Modeling Group at the University of Maryland, College Park (Liang et al. 2012). CWRF provides 30-km gridded data from 1980 to 2015, and the data have been shown to capture summer monsoon rainfall well over South China, which borders Nepal (Liang et al. 2019). We link the rainfall and DHS data at the cluster level using GPS points. To ensure confidentiality, the DHS randomly displaces the GPS locations of rural clusters by between zero and five km (with 1% of clusters displaced by up to 10 km) and urban clusters by between zero and two km. We take the centroid of each 30-by-30 km grid point and link the cluster to its nearest centroid.

We then create a measure of rainfall anomalies during the 2015 monsoon season by first calculating the average total rainfall across the monsoon months (June through September) in each cluster for a 20-year baseline period of 1980 to 1999. We then calculate z-scores for 2015 monsoon rainfall based on deviations from the baseline period. A z-score of -2 therefore indicates that the total monsoon rainfall in 2015 in that DHS cluster was two standard deviations below the cluster's average total monsoon rainfall, which indicates extreme dry conditions. The bottom map in Figure 1 displays cluster-level rainfall z-scores for the 2015 monsoon season, which range from -4.2 to 2.1.

To understand how social and environmental factors mediate the relationship between multiple environmental stressors and food security, we include a set of control variables. These include variables at the household level (age of household head, whether the household head is female, education of household head, and whether the household owns agricultural land), DHS cluster level (urban/rural status, altitude, and historic average daily monsoon rainfall), and district level (Human Development Index (HDI)). HDI data were obtained from Nepal's 2014 Human Development Report, and serve as a composite measure of socioeconomic development based on life expectancy, years of schooling, literacy, and gross national income per capita (Government of Nepal National Planning Commission 2014). Large spatial inequalities in HDI exist within Nepal. The far western regions, as well as some districts in the southeastern part of the country experience the lowest HDI levels, while districts in central Nepal, including Kathmandu and surrounding areas, experience the highest levels.

***Analysis***

In order to understand the independent and joint effects of earthquake exposure and monsoon rainfall anomaly on household food security, we estimate a set of binary logistic regression models predicting the likelihood of moderate or severe food insecurity. The two main predictor variables are whether the household was located in one of the severely-affected districts by the earthquake as well as the 2015 monsoon rainfall z-score at the cluster level. In addition to the independent and joint effects of earthquake exposure and rainfall, we estimate models with earthquake-rainfall interactions and earthquake-rainfall-rural/urban status interactions in order to examine whether exposure to the earthquake magnifies or attenuates the effect of rainfall on food security, and whether this relationship varies between rural and urban populations.

We include interview month as fixed effects to account for seasonal variation in food insecurity during the year. In addition, we include a set of household-, cluster-, and district-level controls, described above, to account for baseline differences in food security between households that vary on a number of dimensions. We account for the complex sampling design in our models through adjusting for stratification, clustered sampling methods, and sampling weights.

We estimate two supplementary models as robustness checks. The first model accounts for potential misestimation of earthquake and rainfall exposure due to migration, which is potentially important given that the earthquake led to the displacement of two million people. Yet research suggests that most people returned to their home communities in the weeks and months following the earthquake. A study using mobile phone data found that in the 14 severely-affected districts, only between 5% and 15% of people remained away from their homes by July 2015 (Wilson et al. 2016). The household questionnaire, conducted between June 2016 and January 2017, did not include a question on the length of residence in the cluster among household members, but the woman's questionnaire asked how long each woman had lived in her current place of residence as well as the district she had lived prior. Using these data, we restricted our analysis to non-migrant households, defined as those in which at least one woman either lived in the current place of residence for at least two years or moved there from another location within the same district. Among the 8,889 households in which the woman's questionnaire was completed, 97% were in the non-migrant sample. Model results among this subgroup were consistent with the main specification.

Second, there are potential issues of selection bias, as some districts in the center-west and western regions of Nepal were lowest in terms of HDI, had the highest levels of food insecurity, experienced the worst drought conditions during the 2015 monsoon, and were not impacted by the earthquake. This could lead us to underestimate the effects of the earthquake on food security. In order to account for this, we estimated a supplementary model that only included the 31 districts that were affected by the earthquake. Model results among this subgroup were consistent with the main specification.

**Results**

Table 1 presents descriptive statistics stratified by whether the household was located in one of the 14 districts severely affected by the earthquake. Approximately 31% of households in each group experienced moderate/severe food insecurity. However, in the severely-affected districts, variability in monsoon rainfall z-score was lower, household head education was higher, households were more likely to live in urban areas, and levels of HDI were higher. This reflects the fact that Kathmandu and other wealthier areas were among those severely hit by the earthquake.

Table 2 presents results from models predicting the likelihood of moderate/severe food insecurity based on earthquake exposure and 2015 monsoon rainfall conditions. Model 1 indicates that households in areas severely affected by the earthquake were not significantly more likely to be food insecure, which is likely due to the fact that large amounts of food aid and other relief assistance were provided to these populations. Model 2 finds a significant negative relationship between rainfall z-score and the likelihood of food insecurity. For each one-unit increase in z-score, a household is 24% less likely to report moderate/severe food insecurity. This is likely due to the links between dry conditions, reduced crop productivity, and higher food prices. Model 3 includes both earthquake exposure and rainfall conditions, and the relationships do not change. Model 4 introduces an interaction between earthquake exposure and rainfall, which suggests that the relationship between monsoon rainfall anomaly and food insecurity varies by earthquake exposure.

Figure 2 presents predicted probabilities of moderate/severe food insecurity based on earthquake exposure-rainfall interactions. Among households in districts that were not severely affected by the earthquake, there is a strong negative relationship between rainfall z-score and the likelihood of food insecurity. For example, a household that experienced a rainfall z-score of -3 has a predicted probability of food insecurity of 44%, whereas the predicted probability of food insecurity is 18% for a household that experienced a rainfall z-score of 1. Among households severely impacted by the earthquake, the relationship between rainfall z-score and food insecurity is positive, indicating that greater rainfall was a risk factor for food insecurity in these areas. In the areas severely affected by the earthquake, monsoon rainfall was associated with a higher-than-average risk of landslides (Rosser et al. 2016). Therefore, more rainfall during the monsoon may have increased landslides, negatively impacting agricultural production, assets, and infrastructure among exposed households and in turn limiting production and access to food.

Table 3 presents results from a model that includes earthquake-rainfall-urban/rural status interactions, and Figure 3 presents predicated probabilities of moderate/severe food insecurity based on these interactions. Among households living in districts not severely impacted by the earthquake, the negative relationship between rainfall z-score and food insecurity is stronger for rural households, many of whom work in the agricultural sector. This suggests that under non-disaster conditions, rural households in Nepal are more vulnerable than urban households to food insecurity resulting from rain shortfalls during the monsoon season. Among households living in districts severely impacted by the earthquake, the positive relationship between rainfall z-score and food insecurity does not differ significantly between urban and rural areas, although the relationship appears stronger for urban households. Among rural agricultural households, the positive effect of rainfall on crop and livestock production may have dampened the negative effect of rainfall and landslide risk. In contrast, for urban households recovering from the earthquake, the risk of landslides associated with heavy rainfall has a greater negative impact on housing, assets, and livelihoods, and in turn on food security.

**Conclusions**

In this paper we examined the independent and joint effects of the 2015 Nepal earthquake and monsoon rainfall anomalies on household food security in 2016. We predicted that exposure to severe earthquake damage as well as low monsoon rainfall would have independent negative impacts on food security. Like Neupane et al. (2018), we found no evidence for a link between earthquake exposure and increased food insecurity, which is likely the result of large disbursements of food aid and recovery assistance to the most severely affected areas. In contrast, experiencing lower-than-average monsoon rainfall in 2015 – a year in which the country received about 25% less rain than normal – was positively associated with food insecurity. This relationship reflects the link between dry conditions, reduced agricultural production, and increased food prices (Ministry of Agricultural Development et al. 2016).

We expected to find a stronger relationship between low rainfall and food insecurity among households in districts severely affected by the earthquake, as experiencing multiple environmental stressors in close succession would lead to greater impacts on food production and income. Low rainfall was associated with a higher likelihood of food insecurity in districts not severely affected by the earthquake, particularly in rural areas where the majority of the population engages in agriculture. However, we discovered a positive relationship between rainfall and food insecurity among households in the districts most severely affected by the earthquake. This was likely due to fact that the 2015 monsoon season, despite being drier than normal, caused landslides at rates 10-20 times that of a normal monsoon season, with landslides concentrated in the areas hardest hit by the earthquake (Rosser et al. 2016). The damage that landslides caused to housing, agricultural assets, roads, and infrastructure likely obstructed access to food and other aid in addition to negatively impacting crop and livestock production.

Climate change is associated with an increased frequency and severity of extreme weather events including droughts, floods, hurricanes, and heat waves. This will lead to new challenges for health and well-being, as populations are increasingly affected by environmental stressors while still recovering from previous stressors. In the context of Nepal, the rapid aid response to the 2015 earthquake appeared to be successful in preventing major increases in food insecurity. However, rainfall conditions were critical determinants of food security in areas severely affected by the earthquake as well as the other regions of the country, though the effects of rainfall differed. Nepal is predicted to experience an increase in both above- and below-normal monsoon rainfall and a greater frequency of extreme precipitation events, leading to more severe droughts, floods, and landslides (World Bank 2013). While Nepal received large amounts of aid to assist in the recovery from the earthquake, extreme weather events are unlikely to garner similar levels of assistance. A greater frequency of these events, without the accompaniment of resources for adaptation and recovery, will leave Nepalis increasingly vulnerable to food insecurity and undernutrition. In order to design effective adaptation strategies to improve global health in the face of climate change, it is critical to better understand how cumulative exposure to extreme weather events impacts populations in a variety of geographic, cultural, and socioeconomics contexts.

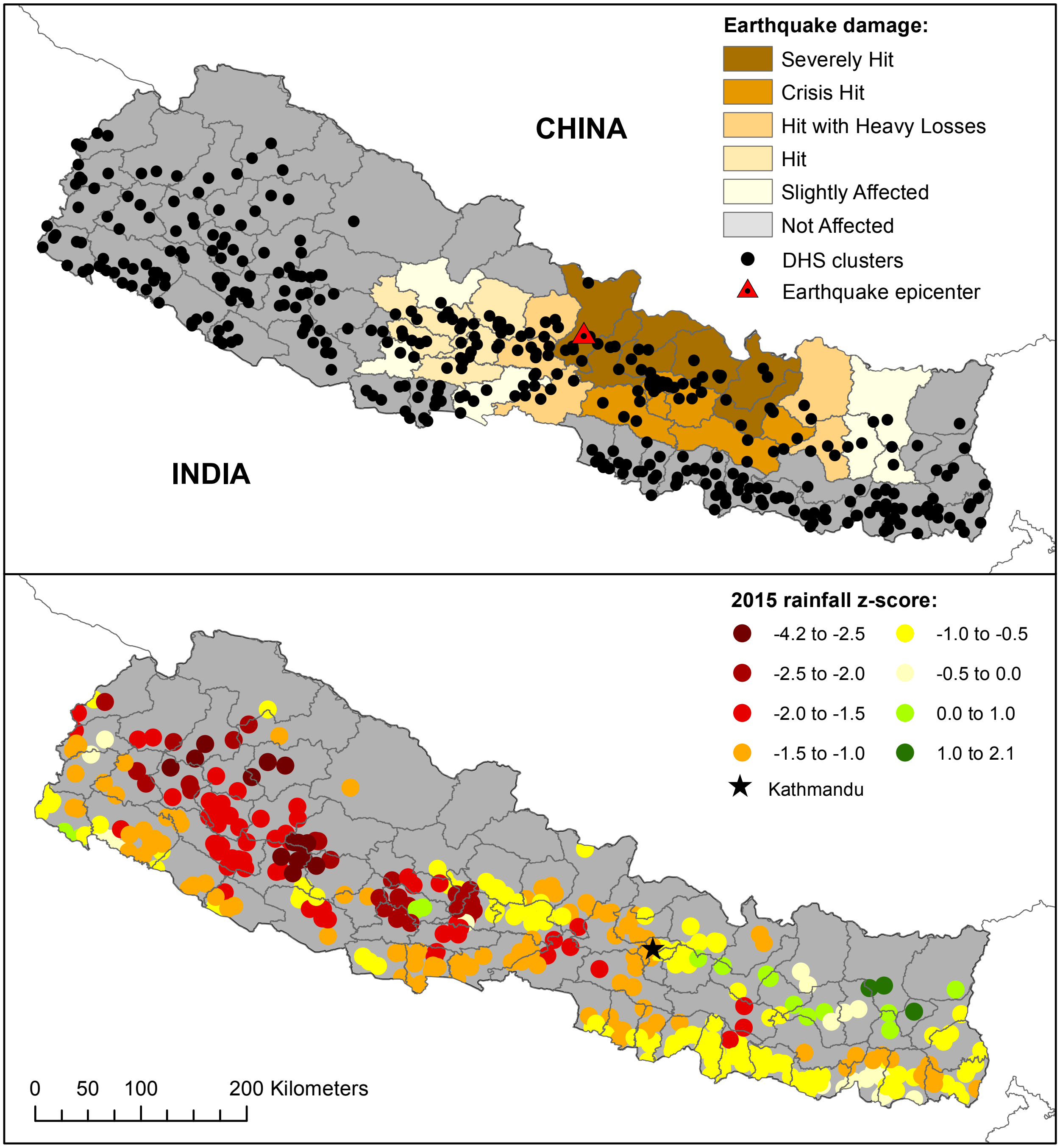


**Figure 1.** Maps of Nepal. Top map includes district-level earthquake damage and location of DHS clusters. Bottom map includes 2015 rainfall z-scores for the DHS clusters.

**Table 1.** Descriptive statistics by level of earthquake damage

| | 14 severely-affected districts | | | | 59 other districts | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean/ proportion | SD | Min | Max | Mean/ proportion | SD | Min | Max |
| Moderate/severe food insecurity | 0.31 | | 0 | 1 | 0.32 | | 0 | 1 |
| Monsoon rainfall z-score | -0.93 | 0.43 | -1.81 | 0.69 | -1.09 | 0.74 | -4.20 | 2.10 |
| Age of household head: | | | | | | | | |
| 15-33 years | 0.27 | | 0 | 1 | 0.23 | | 0 | 1 |
| 34-56 years | 0.49 | | 0 | 1 | 0.52 | | 0 | 1 |
| 57-95 years | 0.25 | | 0 | 1 | 0.25 | | 0 | 1 |
| Female-headed household | 0.30 | | 0 | 1 | 0.32 | | 0 | 1 |
| Education of household head: | | | | | | | | |
| No education or preschool | 0.33 | | 0 | 1 | 0.41 | | 0 | 1 |
| Primary | 0.22 | | 0 | 1 | 0.23 | | 0 | 1 |
| Secondary | 0.28 | | 0 | 1 | 0.26 | | 0 | 1 |
| Higher | 0.18 | | 0 | 1 | 0.10 | | 0 | 1 |
| Household lives in rural area | 0.27 | | 0 | 1 | 0.42 | | 0 | 1 |
| Household owns land | 0.73 | | 0 | 1 | 0.79 | | 0 | 1 |
| Altitude (m above sea level) | 1260.12 | 395.16 | 272 | 2636 | 595.46 | 641.96 | 68 | 3110 |
| Average monsoon daily rainfall (mm) | 15.32 | 5.12 | 2.23 | 20.10 | 8.88 | 5.26 | 1.06 | 35.11 |
| District-level HDI | | | | | | | | |
| <0.450 | 0.04 | | 0 | 1 | 0.34 | | 0 | 1 |
| 0.450-0.499 | 0.41 | | 0 | 1 | 0.40 | | 0 | 1 |
| 0.500-0.549 | 0.06 | | 0 | 1 | 0.20 | | 0 | 1 |
| >0.550 | 0.49 | | 0 | 1 | 0.06 | | 0 | 1 |
| Number of households | 1707 | | | | 9322 | | | |
| Weighted number of households | 2479 | | | | 8541 | | | |

**Table 2.** Odds ratios of the likelihood of moderate or severe food insecurity based on earthquake exposure and rainfall conditions during the 2015 monsoon season

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| District severely affected by earthquake | 0.85 | | 0.91 | 1.63+ |
| Rainfall z-score | | 0.76*** | 0.77*** | 0.72*** |
| Earthquake X Rainfall z-score | | | | 1.83** |
| Household head age [34-56 years is baseline] | | | | |
| 15 to 33 years | 1.30** | 1.29** | 1.29** | 1.29** |
| 57 to 95 years | 0.76*** | 0.75*** | 0.76*** | 0.76*** |
| Female-headed household | 0.73*** | 0.73*** | 0.73*** | 0.72*** |
| Household head education [none/preschool is baseline] | | | | |
| Primary | 0.62*** | 0.62*** | 0.62*** | 0.62*** |
| Secondary | 0.32*** | 0.32*** | 0.32*** | 0.32*** |
| Higher | 0.13*** | 0.13*** | 0.13*** | 0.13*** |
| Household lives in rural area | 1.07 | 1.07 | 1.07 | 1.06 |
| Household owns agricultural land | 0.60*** | 0.60*** | 0.60*** | 0.59*** |
| Altitude of cluster | 1.00*** | 1.00*** | 1.00*** | 1.00*** |
| Average historic monsoon rainfall | 0.98+ | 0.98 | 0.98 | 0.98 |
| District-level HDI [below 0.45 is baseline] | | | | |
| 0.45-0.499 | 0.81+ | 0.87 | 0.89 | 0.88 |
| 0.5-0.549 | 0.59*** | 0.67* | 0.67* | 0.66** |
| >0.550 | 0.58* | 0.61* | 0.64* | 0.65* |
| N | 11029 | 11029 | 11029 | 11029 |

Notes: Models also include fixed effects for month of interview.

+ p<0.1 * p<0.5 ** p<0.01 *** p<0.001

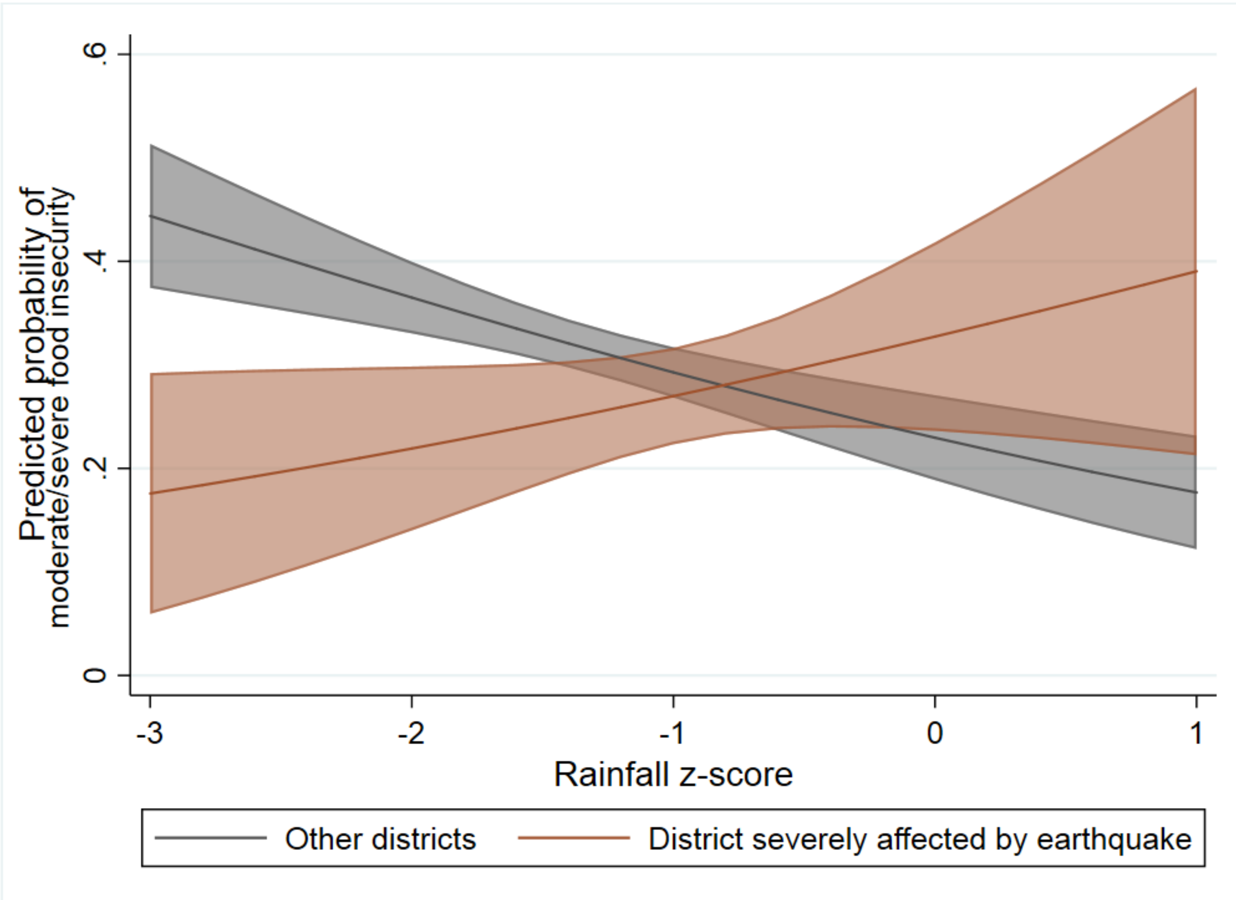


**Figure 2.** Predicted probabilities of moderate or severe food insecurity based on earthquake damage-rainfall z-score interactions, including 95% confidence intervals.

**Table 3.** Odds ratios of the likelihood of moderate or severe food insecurity with interactions between earthquake exposure, rainfall conditions during the 2015 monsoon season, and rural/urban status

| | Model 5 |
|---|---|
| District severely affected by earthquake | 2.28+ |
| Rainfall z-score | 0.85 |
| Earthquake X Rainfall z-score | 2.43* |
| Rural X Rainfall z-score | 0.67** |
| Rural X Earthquake | 0.81 |
| Rural X Earthquake X Rainfall z-score | 0.86 |

Notes: Models also include fixed effects for month of interview and control variables
+ p<0.1 * p<0.5 ** p<0.01 *** p<0.001

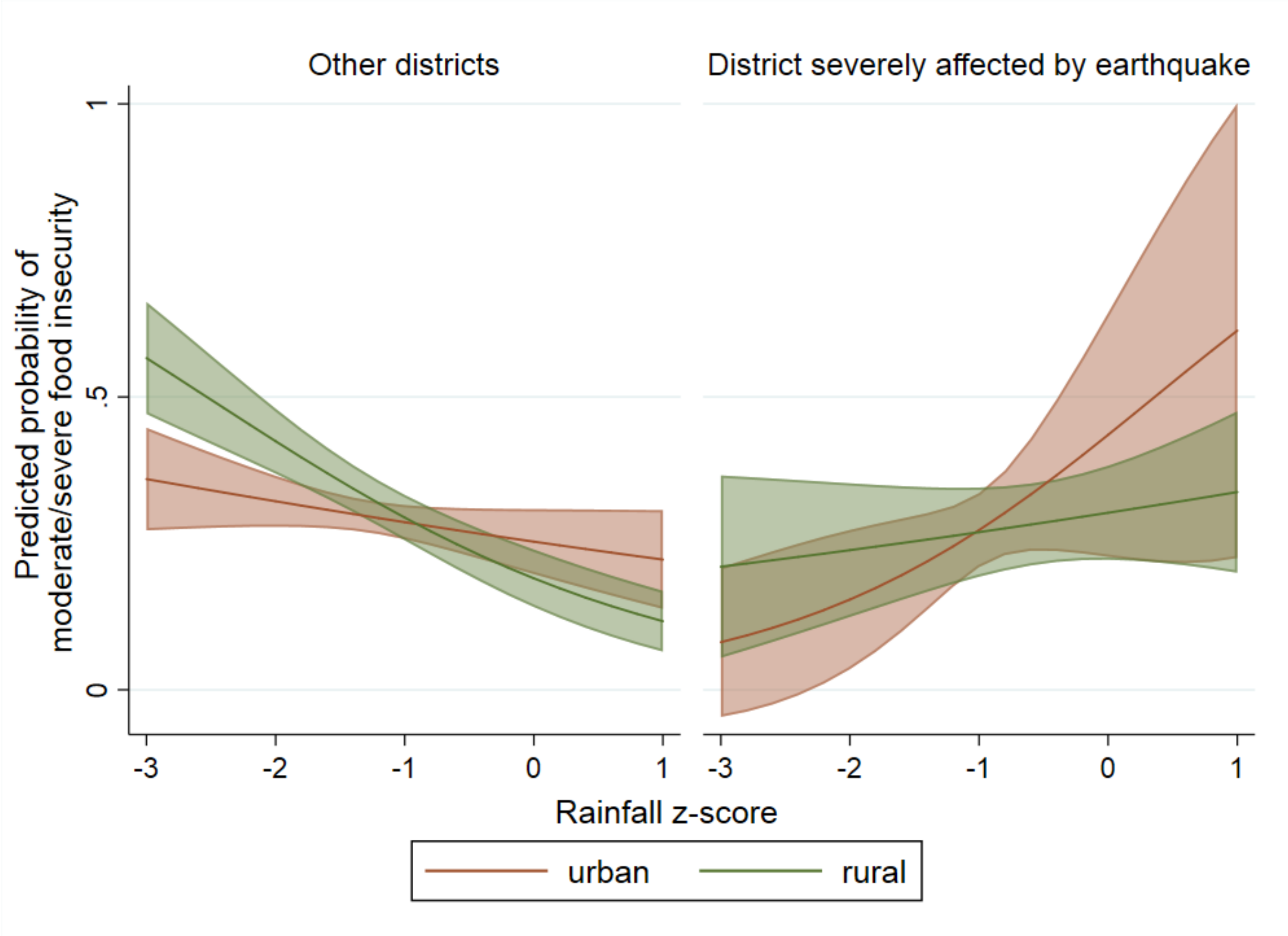


**Figure 3.** Predicted probabilities of moderate or severe food insecurity based on earthquake damage-rainfall z-score-rural/urban interactions, including 95% confidence intervals.

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