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# THE AFTERSHOCK OF THE 2015 NEPAL EARTHQUAKE

## Analyzing District Vulnerability After the Disaster

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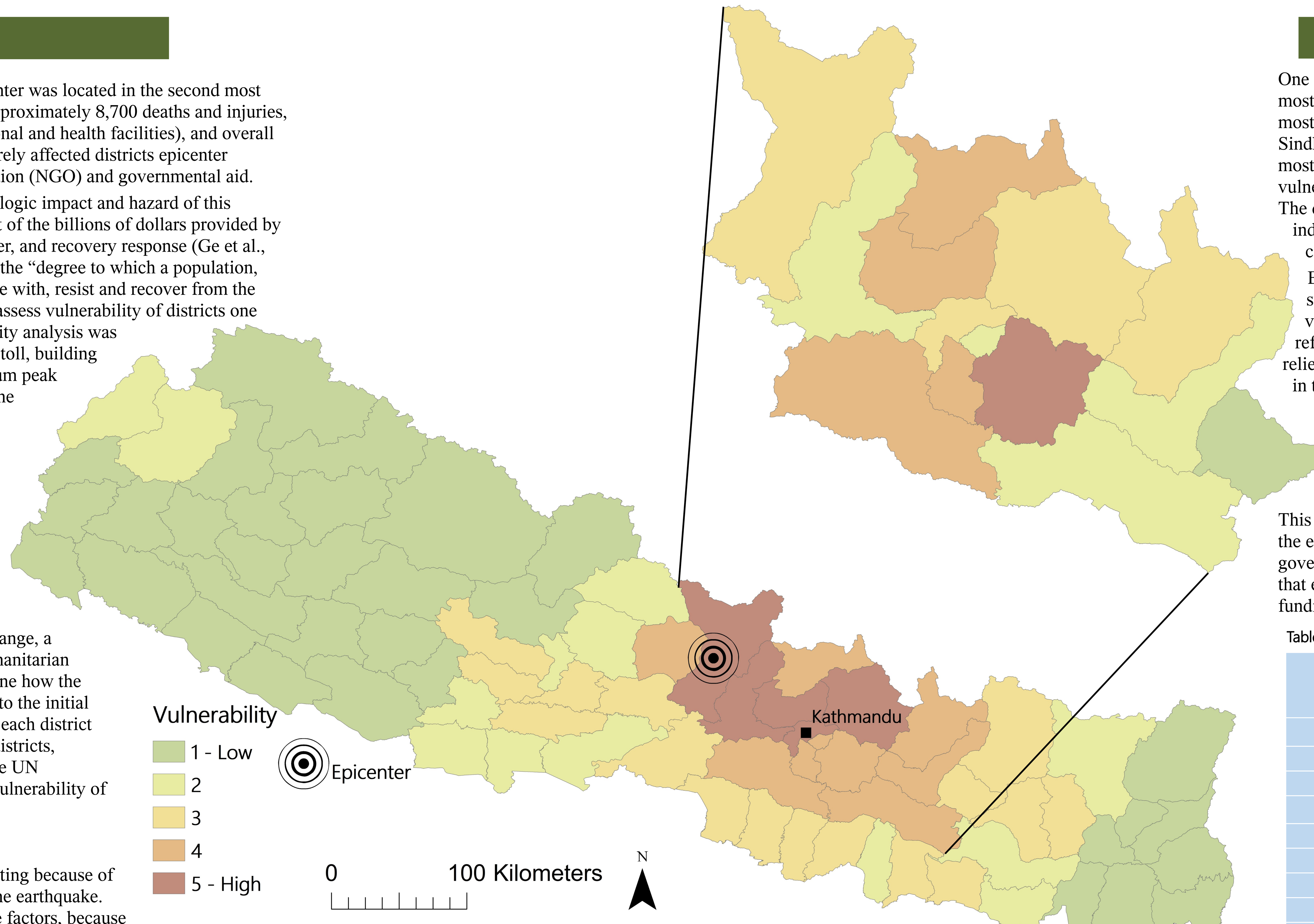
## INTRODUCTION

On April 25, 2015, a magnitude 7.8 earthquake struck Nepal. The epicenter was located in the second most populated city of Nepal, Pokhara. This catastrophic earthquake led to approximately 8,700 deaths and injuries, widespread infrastructure collapse (including but not limited to educational and health facilities), and overall damage to Nepalese livelihood (Zhao, 2015). Fourteen of the most severely affected districts epicenter received most of the international and local non-governmental organization (NGO) and governmental aid.


Many researchers have investigated the real-time geologic impact and hazard of this earthquake, yet they have failed to address the impact of the billions of dollars provided by both local and foreign actors for humanitarian, disaster, and recovery response (Ge et al., 2015; Zhang et al., 2016). Vulnerability is defined as the "degree to which a population, individual or organization is unable to anticipate, cope with, resist and recover from the impacts of disasters" (Wisner and Adams, 2002). To assess vulnerability of districts one month following the earthquake, weighted vulnerability analysis was performed based on the following four factors: death toll, building damage, accessibility of health facilities, and maximum peak ground acceleration (PGA) value. Then, to evaluate the success of relief efforts of the seven months following the earthquake, weighted vulnerability analysis was also performed on the 14 most vulnerable districts. This analysis was based on the community satisfaction regarding the NGO and governmental aid provided in the highly affected regions from the time of the earthquake to December 2015; results reflect the efficacy of relief efforts.




## METHODS

The data used in this study was obtained from Humanitarian Data Exchange, a product of the United Nations (UN) Office for the Coordination of Humanitarian Affairs which is freely available online at data.humdata.org. To determine how the current state of vulnerability of the 14 most affected districts compares to the initial state, the following steps were taken: evaluating the scale of damage in each district immediately after the earthquake to determine 14 of the most affected districts, comparing my findings with the high priority districts determined by the UN Accountability Lab and Local Interventions Group, and analyzing the vulnerability of those top 14 affected districts based on a community survey.

*Weighted Vulnerability Analysis - 1 Month Post-Earthquake*

The factors of building damage and death toll were given greater weighting because of their direct implication of the scale of humanitarian impact caused by the earthquake. Health facility accessibility and maximum PGA values are less accurate factors, because they may depend on confounding variables (See Table 1).

*Focused Weighted Vulnerability Analysis - 7 Months Post-Earthquake*

The community survey implemented by the UN Accountability Lab and Local Interventions focused on what they deemed the 14 most affected districts. The factors used for this analysis were Nepalese responses to the following questions: have your main problems been addressed *(A)*, are you satisfied with what the government *(B1)* and NGOs are doing for you after the earthquake *(B2)*, do you feel your community recovered from the earthquake (C), and what is the current status of your home *(D)*. Survey response options were quantified on a scale of one to five. The quantified responses were averaged per district and the following weighting was used to calculate district vulnerability score:

$$0.1*(B1 + B2) + 0.325*(A + D) + 0.15*(C)$$

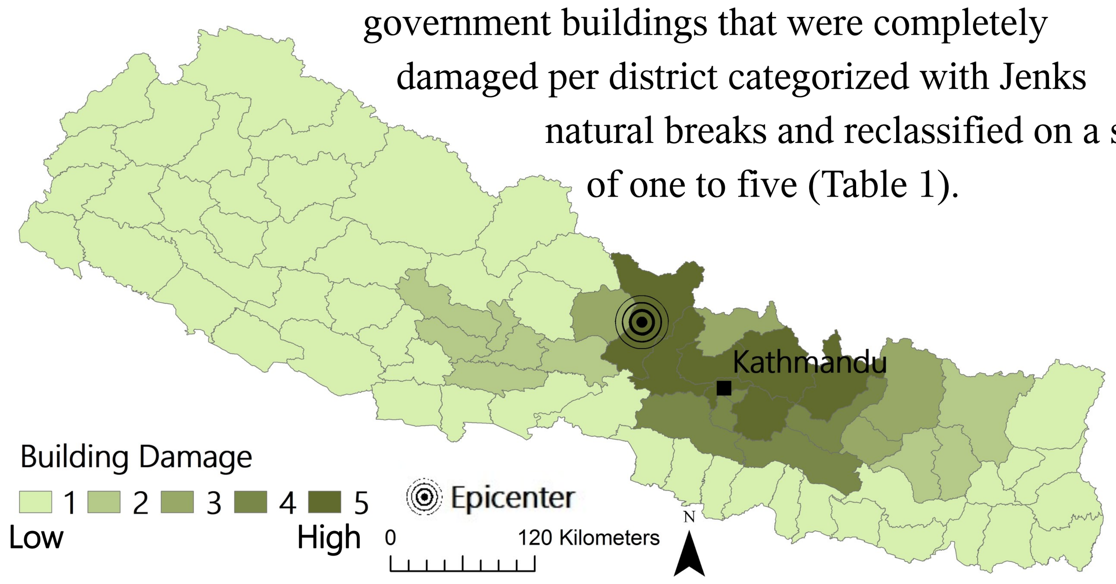
Table 1. Reclassification Criteria

| Factor | Weight (%) | Reclassification Scale | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| **Building Damage** (number of buildings in thousands) | 30 | < 1 | 1 – 5 | 5 – 10 | 10 – 27 | > 27 |
| **Death Toll** (number of people) | 30 | < 40 | 40 – 440 | 440 – 730 | 730 – 1200 | >1200 |
| **Maximum PGA Value** ($m/s^2$) | 20 | 0 – 3 | 3 – 7 | 7– 17 | 27– 30 | > 30 |
| **Health Facility Accessibility** (number of health facilities) | 20 | > 1400 | 900 – 1400 | 500 – 900 | 200– 500 | < 200 |

* Table values for building damage and maximum PGA value are rounded to the nearest integer

## BUILDING DAMAGE

Prior to the earthquake, the design of Nepal buildings did not thoroughly account for disaster risk or hazard. The earthquake shockwaves caused buildings to be demolished and collapse. The total number of public and government buildings that were completely damaged per district categorized with Jenks natural breaks and reclassified on a scale of one to five (Table 1).




## REFERENCE

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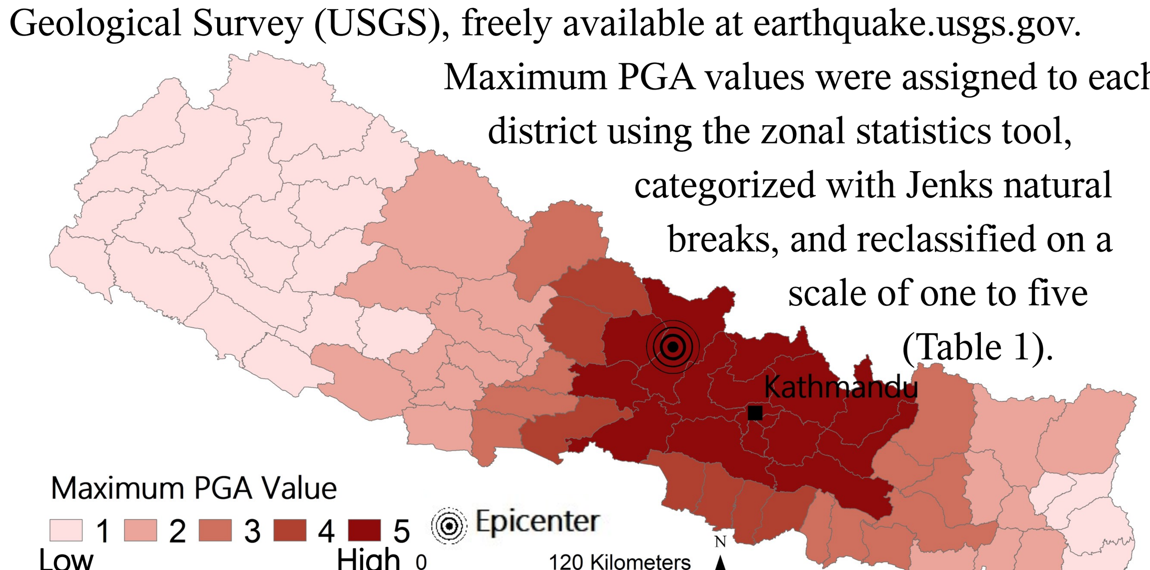
Wisner, B., & Adams, J. (Eds.). (2002). *Environmental health in emergencies and disasters: a practical guide. World health organization.*

Zhang, H., Lee, S., & Ge, Z. (2016). Multiarray rupture imaging of the devastating 2015 Gorkha, Nepal, earthquake sequence. *Geophysical Research Letters, 43(2), 584-591.*

Zhao, B. (2016). April 2015 Nepal earthquake: observations and reflections. *Natural Hazards, 80(2), 1405-1410.*

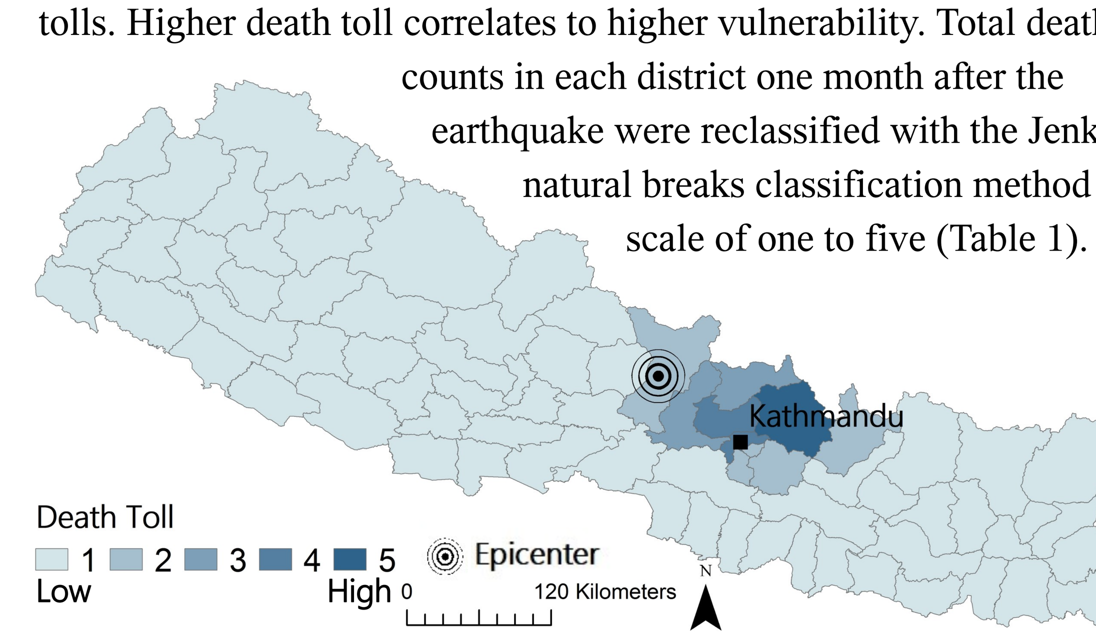
## MAXIMUM PGA VALUE

PGA values indicate the largest recorded increase in velocity of a particle on the ground (USGS). Comparing PGA values helps detect which areas experienced more ground shaking from an earthquake. An area with a greater PGA value is likely to have more damage and community displacement. The original PGA raster data was taken from the U.S. Geological Survey (USGS), freely available at earthquake.usgs.gov. Maximum PGA values were assigned to each district using the zonal statistics tool, categorized with Jenks natural breaks, and reclassified on a scale of one to five (Table 1).




## DEATH TOLL

Earthquakes disrupt communities by increasing infection incidence and physical harm frequency; thus, they are associated with increased death tolls. Higher death toll correlates to higher vulnerability. Total death counts in each district one month after the earthquake were reclassified with the Jenks natural breaks classification method on a scale of one to five (Table 1).




## DISCUSSION

One month after the earthquake, the average vulnerability score of the 14 most vulnerable districts was 3.7. Sindhupalchok was found to be the most vulnerable, with a score of 4.6. Seven months after the earthquake, Sindhupalchok was found to be less vulnerable and Kavrepalanchok the most vulnerable district. The average vulnerability score of the 14 most vulnerable districts decreased after seven months to 3.4. (See Table 2). The decrease in vulnerability score seven months after the earthquake indicates the successfulness of disaster relief efforts and helps to predict continued recovery in affected communities after December 2015.

Because the factors used for May and December 2015 vulnerability state analysis differ, the potential extent of comparison between vulnerability levels is limited. The community survey data directly reflects the personal feelings of affected, individual Nepalese towards relief progress. However, the possible sampling bias is not accounted for in the results. Furthermore, the vulnerability factors used in calculations were chosen from available data; vulnerability is multifaceted and depends on many physical, environmental, and socio-economic variables. The weighted vulnerability analysis used could be improved by accounting for other drivers of vulnerability and by modifying the assigned weight distribution.

This project will help to promote and further research on how to evaluate the efficacy of disaster response. Both local and global NGOs and governmental policymakers may benefit from using a GIS-based method that emulates the disaster vulnerability of a country and suggests where funding and resources are necessary or better allocated.

Table 2 .Vulnerability Ranking

| Rank | District (May 2015) | District (December 2015) |
|---|---|---|
| **1— Most Vulnerable** | Sindhupalchok | Kavrepalanchok |
| **2** | Kathmandu | Makwanpur |
| **3** | Nuwakot | Nuwakot |
| **4** | Dhading | Lalitpur |
| **5** | Gorkha | Rasuwa |
| **6** | Dolakha | Gorkha |
| **7** | Kavrepalanchok | Kathmandu |
| **8** | Lalitpur | Dolakha |
| **9** | Bhaktapur | Sindhupalchok |
| **10** | Rasuwa | Bhaktapur |
| **11** | Sindhuli | Dhading |
| **12** | Ramechhap | Ramechhap |
| **13** | Makwanpur | Sindhuli |
| **14— Least Vulnerable** | Lamjung | Okaldhunga |

Data Sources: Humanitarian Data Exchange, USGS, ESRI GIS

Coordinate System: World Geographic System 1984

## HEALTH FACILITY ACCESSIBILITY

Nepal health care services are primarily distributed at the district level through sub-health posts, health posts, primary health centers, and district hospitals. Assuming Nepalese would travel (by foot or by car) to the closest health facility for medical attention and supplies, total number of health facilities within five kilometers of a road per district were calculated using proximity tools. These values, indicative of health facility accessibility, were reclassified with the Jenks natural breaks classification method on a scale of one to five (Table 1).