

# Japan Nuclear Power Plant Vulnerability Analysis

## Introduction

On March 11, 2011 a magnitude 9.03 earthquake hit off the coast of Japan triggering a massive tsunami destroying many coastal communities along the Tohoku region of Northern Honshu resulting in over 15,000 deaths as well as extensive damage. As if that destruction and loss of life were not bad enough, the tsunami damaged the Fukushima Daiichi Nuclear Power Plant leading to a full meltdown of the three of the plants four reactors. Radiation was released into the atmosphere and is an ongoing environmental and public health issue. Families have been displaced, farmland damaged and already studies have shown an increased risk in cancer for children who were living near the Daiichi power plant. The full extent of the damage resulting from these meltdowns has yet to be realized.

This disaster highlighted the risks of nuclear power. Due to extreme backlash of the Japanese public all of Japan's nuclear power plants have either been closed or suspended for safety inspections causing power shortages

and rolling blackouts in some areas that depended heavily on nuclear power. Japan however faces a conundrum that while it is a country prone to natural disasters, it is also deficient resources needed for alternative energy sources. Currently over 80% of its energy needs are imported. Additionally, while not without its risks, there are arguably some advantages of nuclear power compared to coal and natural gas.

Understanding which plants are at higher risk to damage from natural disasters such as earthquakes and tsunamis is essential for deciding which, if any, of these power plants should be recommissioned. In addition to natural disasters, Japan must also address the issue of rising water levels. Since many of the power plants are near the shore, erosion of coastlines could affect the longevity of current power plants and even result in environmental hazards for decommissioned plants. This project seeks to analyze the vulnerability of nuclear power plants in Japan, specifically related to earthquakes, tsunamis and rising water.

## Methods

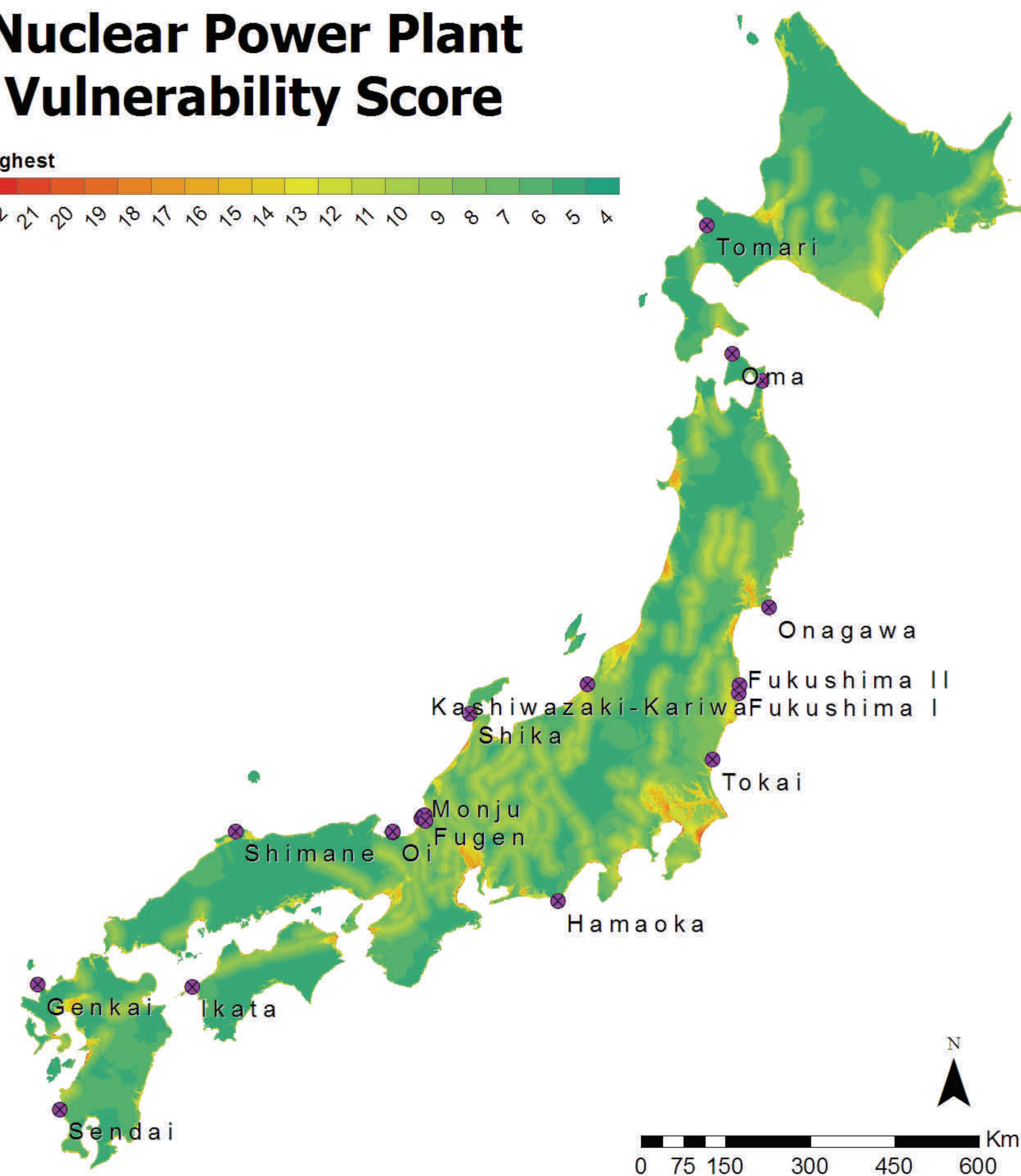
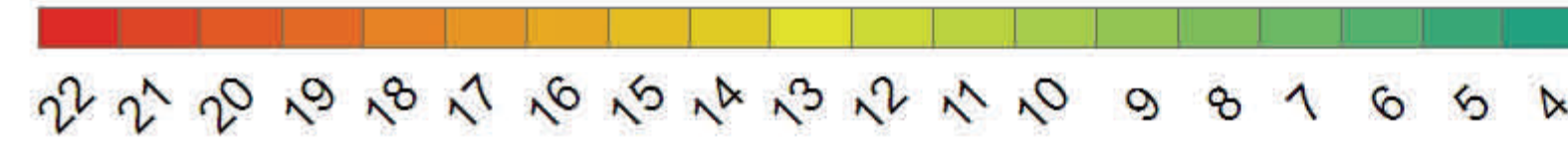
Power plant vulnerability was determined by identifying areas at elevated risk to earthquakes, tsunamis, and rising water levels. Historical earthquakes along with proximity to faults lines were used to calculate an earthquake vulnerability score. The locations of earthquakes of magnitude five or greater dating back to 1960 were used to generate an earthquake density map. Areas with highest density of earthquakes were considered to be more risky and assigned a score of 5. Japan also has over 100 active fault lines. Areas within 10 kilometers of a fault line assigned a risk level of 5 and then each 5 kilometer increment out received one score lower. The earthquake density score and fault line proximity score were combined for

an overall earthquake vulnerability score between 1 and 10. Initially the tsunami vulnerability analysis was to be based on the methodology outlined by Sinaga et al in the paper "GIS Mapping of Tsunami Vulnerability: Case Study of the Jembrana Regency in Bali, Indonesia." This method uses a weighted average of topographic elevation, slope relation to tsunami direction, coastal proximity and coastal shape to determine which areas are at high risk for damage due to a tsunami. However due to time constraints, data acquisition difficulty, and computer data overload issues only topographic elevation and coastal proximity were included in the final analysis. As with earthquake analysis, maps were generated

assigning a level 5 to the areas at most risk and the two maps were combined to generate a tsunami vulnerability score between 2 and 10. In addition to natural disasters, Japan must also address the issue of rising water levels. It has been estimated that water levels could rise over 1m in the next century or even as much as 3.2m. Elevation data was used to score plants that would be affected by this rise in sea level with the most vulnerable assigned a score of five. All three scores were combined to produce an overall vulnerability score ranging from 4 to 22. Plants were then assigned scores based on their location in the overall vulnerability score map.

## Nuclear Power Plant Vulnerability Score

Highest



## Nuclear Power Plant Vulnerability

Nuclear Power Plant	Score
Fukushima I	18
Kashiwazaki-Kariwa	15
Higashidōri	14
Tōkai	12
Fukushima II	12
Mihama	11
Monju	11
Fugen	11
Tsuruga	11
Ikata	10
Takahama	10
Ōi	10
Genkai	9
Sendai	9
Shimane	9
Shika	9
Hamaoka	9
Tomari	9
Ōma	9
Onagawa	7

## Results and Limitations

Results are summarized in the table above. Total vulnerability scores for the nuclear powers ranged from 7–18 with the majority of the plants in the 9–12 range. The Fukushima Daiichi I Nuclear Power Plant, one of the plants damaged in the 2011 disaster, received the highest score of 18. The second highest scoring plant was Kashiwazaki-Kariwa Nuclear Power Plant. This plant also suffered damage from an earthquake in 2007 and was shut down for 21 months for repair prior to being temporarily closed in April 2011. This analysis identified both of those plants as being in high risk areas. The plant in Onagawa received a score of seven and seven other plants received a score of nine. These plants have a moderate vulnerability for damage and could be considered to be re-

commissioned to help the Japanese power supply. Additionally, since this map covers all of Japan, it could also be used for identifying new areas that may be more suitable for higher risk facilities such as nuclear power plants. This analysis was limited since the tsunami vulnerability could not be adequately assessed. Also, equal weights were giving to threats from earthquakes, tsunamis and rising water levels. A more in-depth analysis could review previous literature to determine more accurate weights for these threats and construct a vulnerability equation taking this knowledge into account. This would produce a more reliable score and better assist in determining which plants are at the most vulnerable to damage.

Cartographer: Carrie Brown

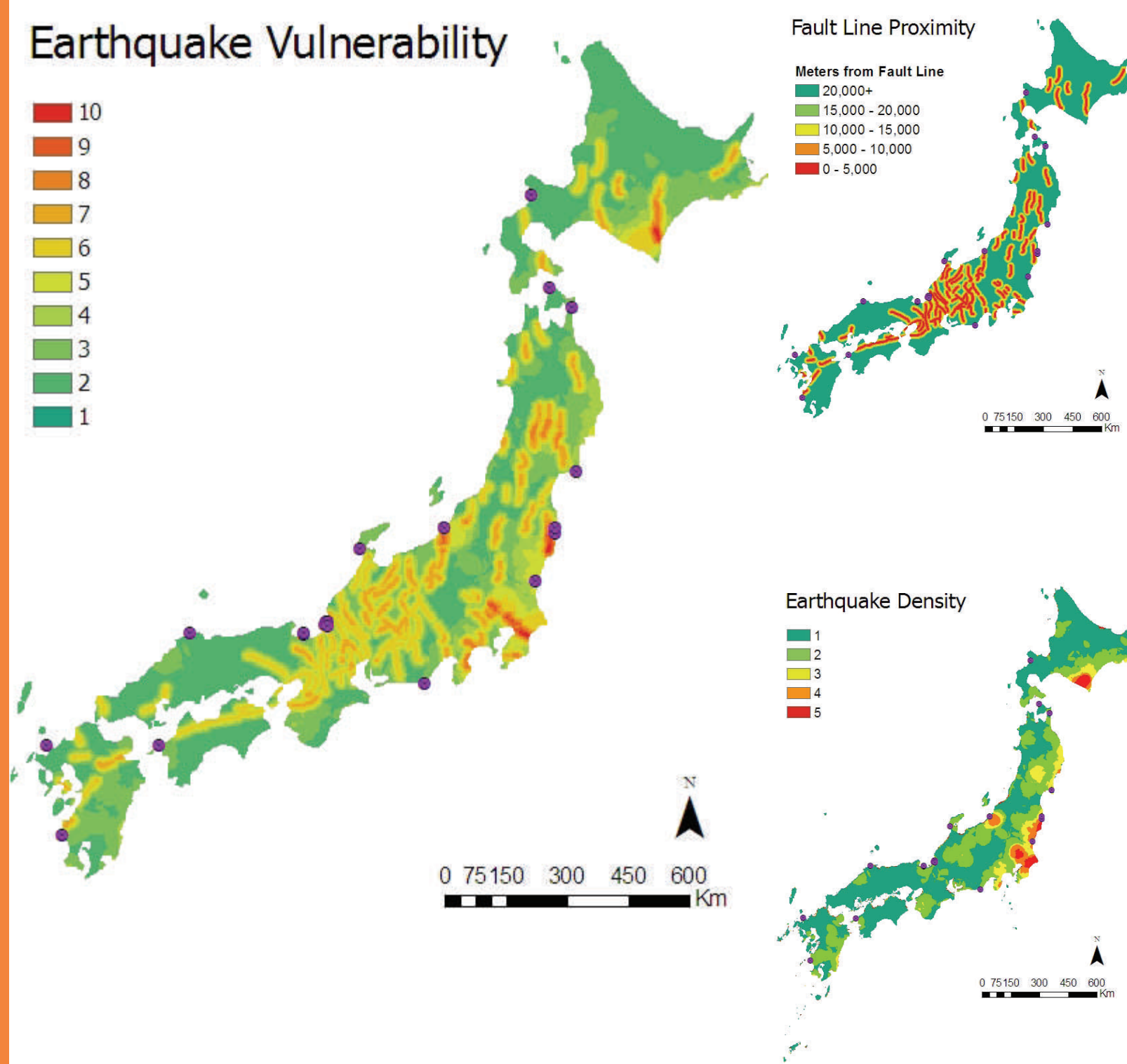
Data Sources: Tufts GIS Confluence, IRIS, US Geological Survey, DIVA-GIS, Japan Headquarters for Earthquake Research Promotion  
Projection System: WGS 1984 PDC Mercator  
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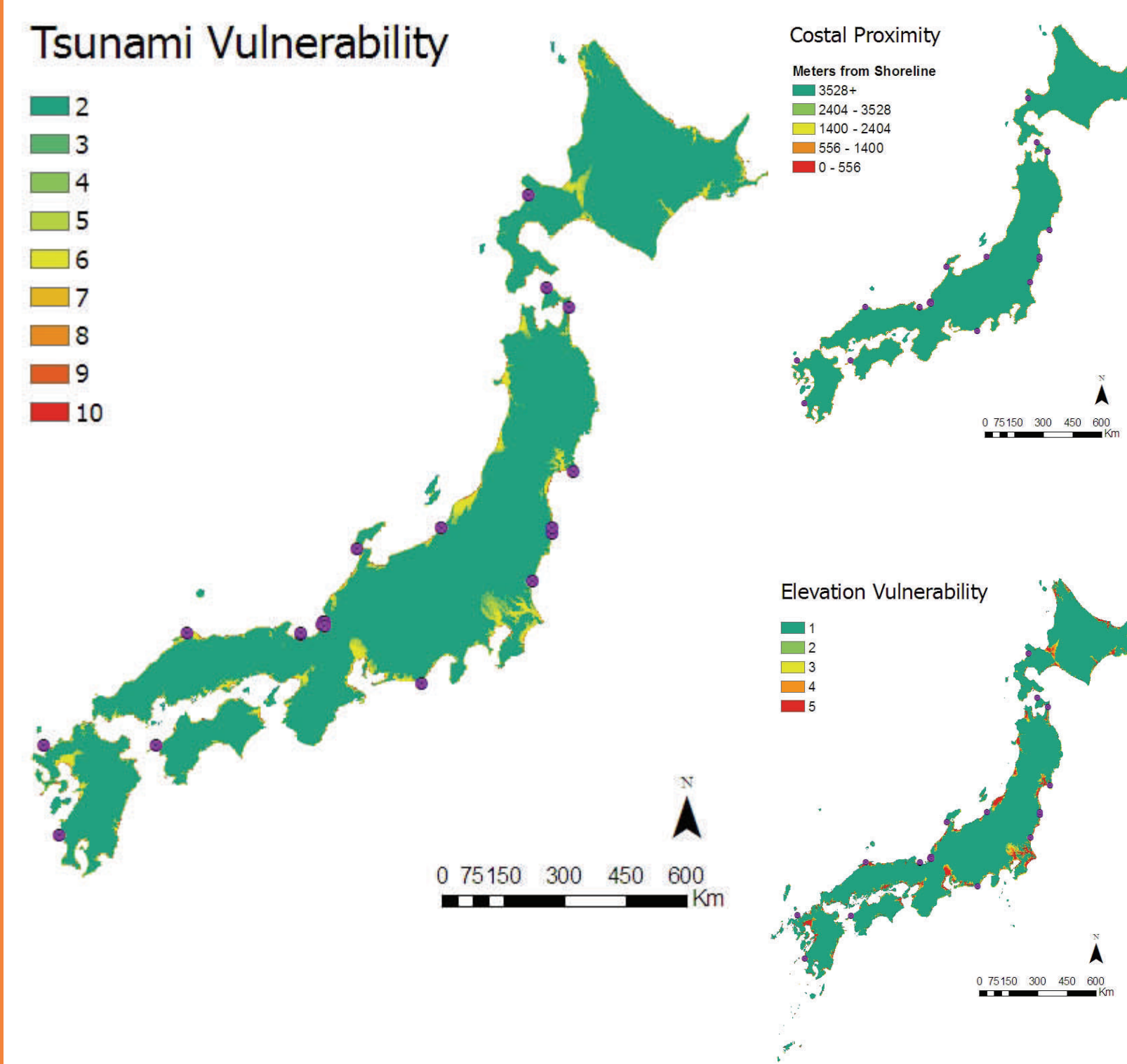
EARTHQUAKES

### Earthquake Vulnerability



TSUNAMIS

### Tsunami Vulnerability



WATER LEVEL

### Water Level Rise

