

# Flood Vulnerability in Bangladesh

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## Introduction

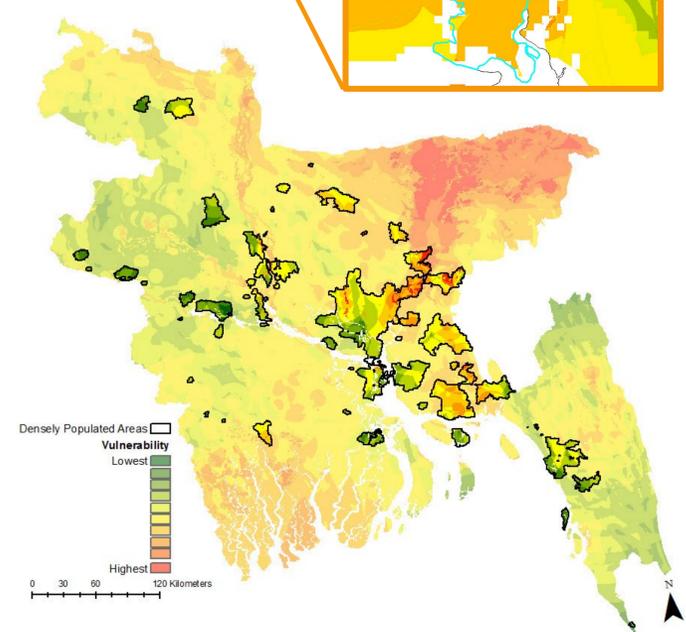
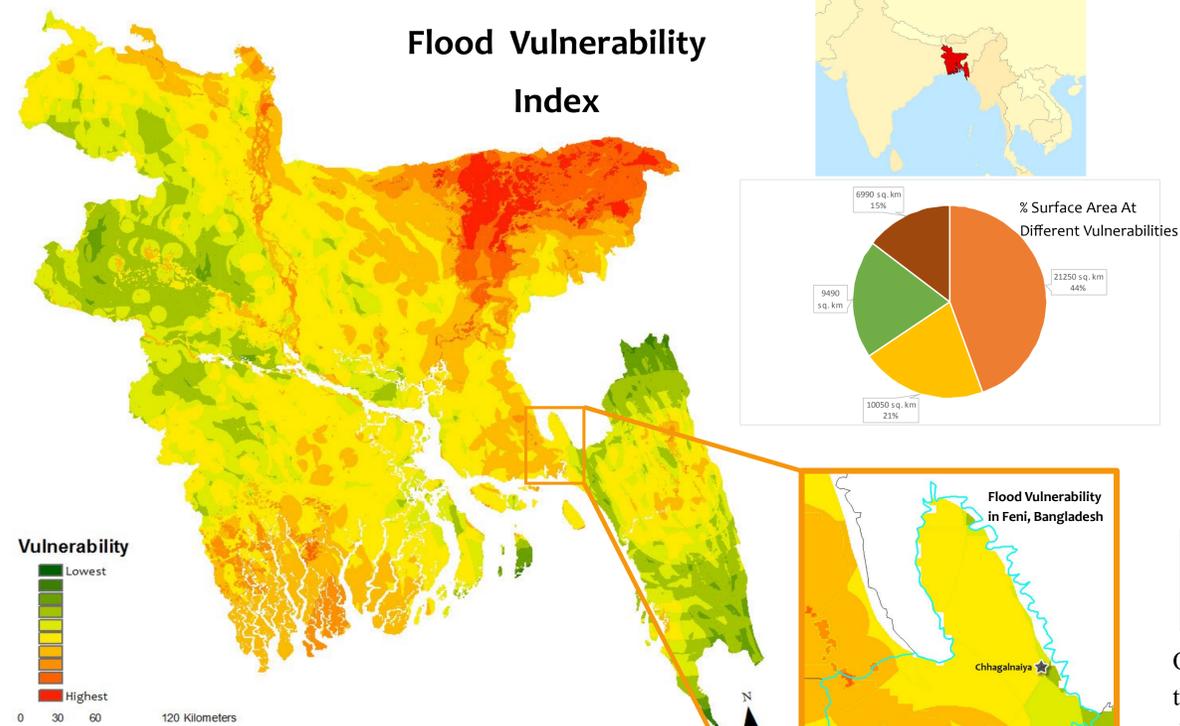
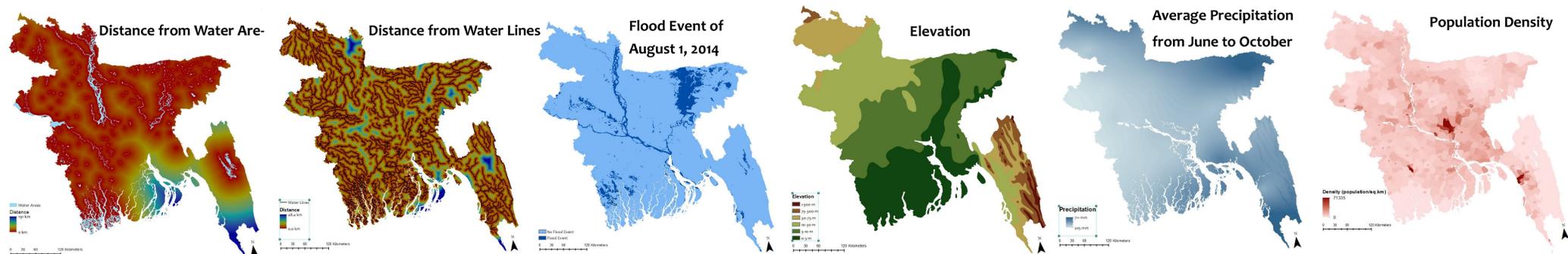
Bangladesh, a small coastal country bordered by India and Burma, is home to three of the world's largest river systems: the Padma (Ganges), Jamuna (Brahmaputra), and Meghna rivers. Most of Bangladesh is low lying and flat, with a quarter of the land under 1m above sea level (1). From June to October, monsoons cause rivers to burst their banks and flood the fields. The flat floodplains are ideal landscapes for growing rice and jute and for shrimp farming, but these natural conditions make Bangladesh especially vulnerable to destructive flooding. In addition, the coastal areas experience regular tropical cyclones and high river flow from the Himalayan snowmelt. Changing weather conditions brought about by changing climate, such as heavier rainfall, more frequent and severe tropical cyclones, and increased snowmelt, are predicted to cause heavier floods and rising sea levels that put much of the country at risk.

The goal of my project is to identify which regions of the country are most vulnerable to flooding by looking at different factors that impact likelihood of floods. I focus on elevation, average precipitation during the monsoon season, proximity to surface water bodies, and past flood history in order to determine a flood vulnerability index that will highlight least vulnerable and most vulnerable areas. In addition, I look specifically at the flood vulnerability of the most densely populated areas to gain a better understanding of how the flood risk would impact those communities.

## Data and Methods

I created a flood vulnerability index to map the regions of Bangladesh that are most vulnerable to flood by weighted raster addition of elevation, precipitation, proximity to water bodies, and past flood event. I chose to use the Equidistant Conic Projected Coordinate System in order to accurately conduct distance analysis. I acquired 2012 data on the administrative zones of Bangladesh from the Database of Global Administrative Areas (GADM) and 1992 data on water areas and water lines from the Digital Chart of the World. I used Euclidean Distance on the water data to create raster files of proximity to water bodies, and I reclassified the data into 10 and 9 classes respectively, with the highest class as the closest to water. I used 2001 data on elevation from the United States Geological Survey (USGS) and 2005 data on monthly mean precipitation from WorldClim. I converted the elevation data to a raster file of 6 classes, with the highest class being the lowest elevation. I used Map Algebra to combine 5 of the 12 precipitation rasters into one raster by averaging the files from June to October, the rainiest months. I then reclassified the precipitation into 9 classes, with the highest class corresponding to the heaviest rainfall. I also found data recording a flood event on 1 August 2014 from the Dartmouth Flood Observatory. I converted the data into a raster with two classes where 7 indicates previous flood event and 1 indicates no flood event. With these five raster files I did a raster addition, with the past flood history feature weighted 11%, and the other four weighted 22%. With the resulting vulnerability map, I calculated the percentage of surface area that had the highest vulnerability (the regions in red tones), the percentage that had moderate-to-high vulnerability (orange tones), and the percentages with moderate-to-low or low vulnerability (yellow and green tones).

To understand the impacts, I looked at how population density intersects with vulnerability. I acquired 2000 data on population density from the Socioeconomic Data and Applications Center (SEDAC). I reclassified the data into 10 classes where 10 was the highest population. Then I extracted the vulnerability index using regions that were greater than 4 as a mask. Laying the clipped layer over the rest of the index allowed me to visualize what kind of vulnerability the most population dense regions of Bangladesh experience.



## Implications

About 6,990 sq. km of Bangladesh's surface area, roughly 15%, is found to be highly vulnerable to floods, while 21,250 sq. km, roughly 44%, is moderately vulnerable. The most vulnerable regions are in the northeast and southwest of Bangladesh. The districts that are most affected are Sylhet and Sun Amgonj. Flood vulnerability maps like this one are useful because they allow public officials to make better informed policy decisions regarding the distribution of resources for flood mitigation. In addition, comparing flood vulnerability alongside population density allows policymakers to anticipate which areas will need immediate attention during a potential crisis. Areas that are more densely populated will be more impacted and need more emergency supplies and different strategies to address flood related crises. By recognizing which areas are vulnerable to flooding and which areas will be more impacted, public officials can deal with floods more efficiently and reduce loss of life and property.

## Next Steps

One of the more noticeable drawbacks of the analysis is the datasets themselves. The data ranges from 1992 to 2014. Having data from different years decreases the quality of the analysis since it reduces the accuracy. A dataset of waterbodies from 1992 may not reflect the current conditions of waterbodies since rivers can be incredibly dynamic. One way to improve this map is to control for time by using datasets that are around the same time frame or checking the older datasets to confirm that their conditions are still the same.

Another potential drawback is that the datasets were not checked for linearity against each other. There may have been a correlation between two datasets because of a confounding variable that would cause a factor to be double counted. For example, a previous flood event would be influenced by precipitation, elevation, etc. Including a previous flood event could double the influence of the other factors. Testing the correlation between the different factors would improve my understanding of how the factors influence each other and thereby, how they influence the vulnerability analysis.

The factors I was able to use in my analysis are only a sample of the myriad that influence flooding. Some important factors I did not consider are land cover, soil type, and frequency and severity of tropical storms. Certain types of land cover and soil type encourage surface runoff and reduce seepage, thus exacerbating floods. With increasing urbanization, more vegetation and dirt roads are replaced with impermeable asphalt flyovers causing increased runoff. Changing land cover is increasingly becoming a bigger influence on flooding. Conducting analysis with more potential factors will allow the map to more accurately model flood vulnerability.

Finally, Bangladesh experiences different types of flooding—flash floods, monsoon floods, rain fed floods, and bank floods, to name a few—that are caused by different factors. This map looks at floods in general, which does not portray a complete understanding. Rather, looking into the conditions that lead to specific types of flooding will create a more nuanced understanding of the different types of floods in Bangladesh.