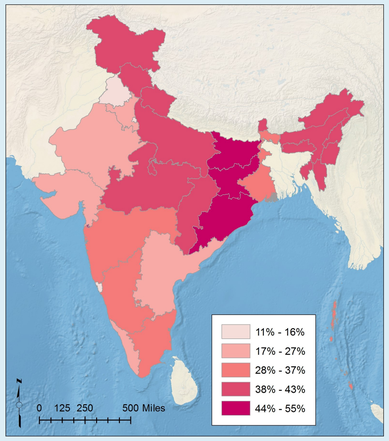
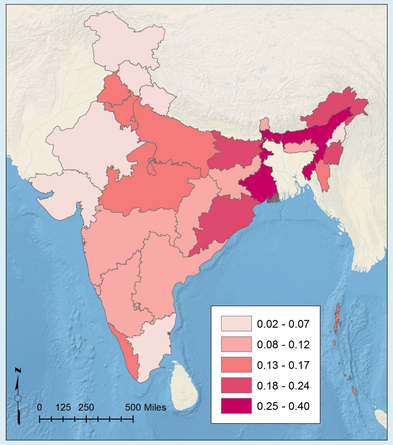
# Refugee Crisis: Predicting Future Climate Emigration from India

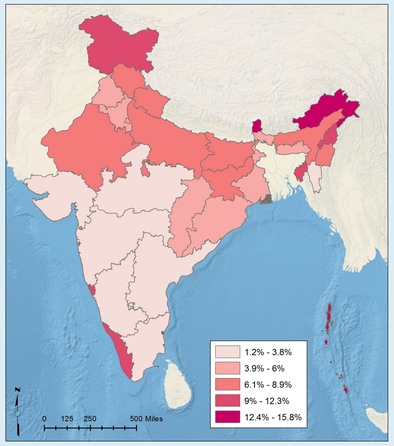
POVERTY RATE (STATE)




VIOLENT CRIMES PER 1000 PEOPLE (STATE)




UNEMPLOYMENT RATE (STATE)



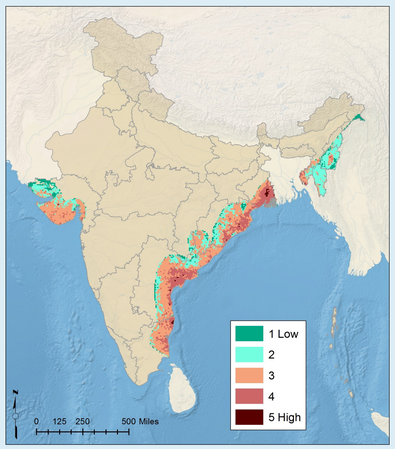

## METHODS

Although the aim of my project was to identify potential hotspots for climate emigration from India, socioeconomic forces also play a large role in influencing migration patterns, and thus I included both socioeconomic and environmental variables in my analysis. I created maps of three socioeconomic factors: poverty, displayed as percentage of individuals below the poverty line by state, unemployment, represented by the unemployment rate by state, and violent crime, displayed as a rate of violent crimes per 1000 people by state. This involved joining data by state from IndiaStat with a layer of Indian states (2011) and symbolizing the layers based on the relevant variable, including calculating a violent crime rate by state.

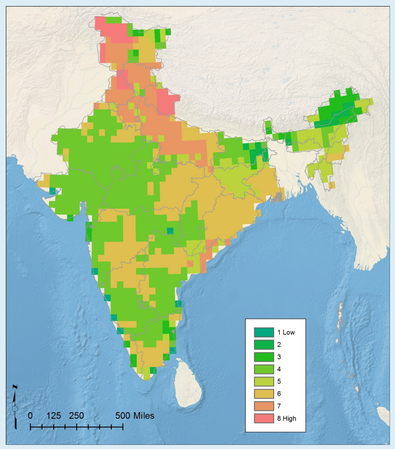
Additionally, I created maps of environmental factors, including tropical cyclone risk, flooding risk, and drought severity, all shown as rasters. I created the drought severity index as a means of combining several variables that would contribute to drought risk and damage, including projected change in agricultural yield (World Bank), projected precipitation change (World Bank), and historic drought events. I used the raster calculator tool to add these variables together, weighting the historic drought events twice as much as the other layers to ground the data in a historical context. I overlaid the states layer for visual context.

Finally, I created a raster combining several variables to calculate a "Climate Emigration Index," predicting the likelihood of climate emigration (migration resulting from climate change effects) from that region. The variables included in the analysis included tropical cyclone risk, drought severity, flooding risk, change in average annual temperature, unemployment, poverty, and violent crime. I calculated zonal statistics by state to determine which states have the highest probability of climate emigration.

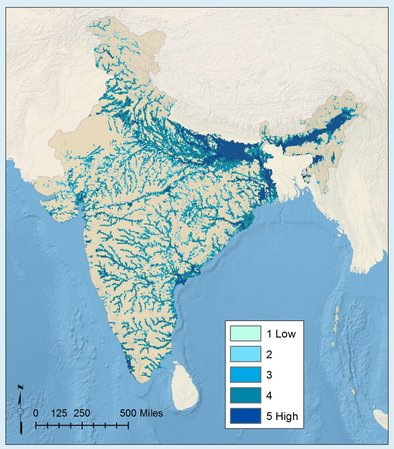
TROPICAL CYCLONE RISK



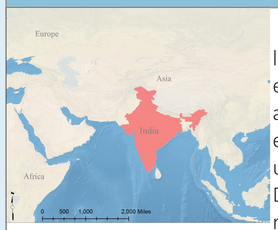

DROUGHT IMPACT SEVERITY




FLOODING RISK




## INTRODUCTION



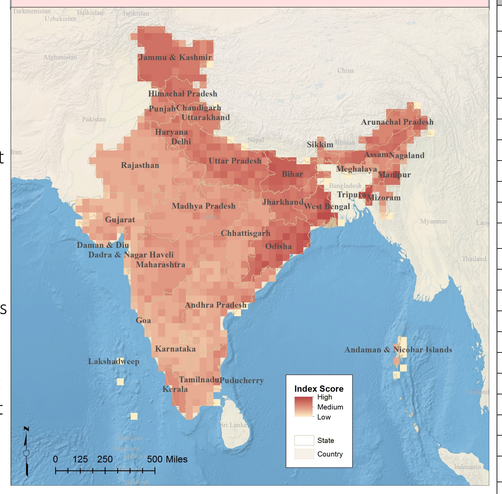

The global climate has risen by approximately 1.1 degrees Celsius (2.0 degrees Fahrenheit) since the late 19th century, and 2016 was the hottest year ever on record. This climate change has had cascading effects, such as glacial shrinkage, sea level rise, extreme temperature and weather events, and ocean acidification. We can expect that these effects will only intensify, as positive feedback loops often exacerbate these processes (NASA). When coupled with socioeconomic factors such as poverty, unemployment, and violence, climate change threatens the livelihoods of billions of people worldwide. Droughts and soil erosion lead to lower agricultural yield, while sea level rise and extreme weather events render some areas uninhabitable (Black et. al 2013). While some communities may be able to adapt to climate change, others may be left with few resources and options, causing its residents to migrate elsewhere.

I chose to study India because as such a large country, India experiences a variety of climates and is impacted by a range of natural phenomena, such as tropical cyclones, droughts, and earthquakes. My goal was to identify hotspots for future emigration both by state and on a more granular level by analyzing the "push" factors that may cause someone to choose to leave a region in the face of climate change.

## RESULTS AND LIMITATIONS

The final "Climate Emigration Index" presents a spatial representation of the probability of climate emigration across India.

CLIMATE EMIGRATION INDEX




The map shows that climate emigration is most probable in the northern and western areas of India. This is further displayed by the table, which shows the score assigned to each state (1 is the lowest probability, 22 is the highest probability). The state with the highest score is Bihar, India's most flood-prone state (FMIS Bihar), riddled with corruption and poverty (The Economist). Also topping the list is Manipur, a state "gripped by violence" (BBC).

Conversely, the states with the lowest climate emigration score include Karnataka, Gujarat, Goa, Tamilnadu, and Rajasthan, states with relatively low flooding or tropical cyclone risk and relative socioeconomic strength. This discussion is important when it comes to shaping policy surrounding climate adaptation and migration. Both governmental bodies within India and internationally should prepare for emigration from these regions and shape policy accordingly.

However, the data present some limitations. The states layer (ESRI) shows data from the 2011 census, while many of the other layers were created either prior to or after 2011. Since India's state borders have changed several times since some of the layers were created (including carving the state of Telangana out of Andhra Pradesh in 2014), the data may not match the exact spatial area which it was originally intended to represent. Some of the rasters include very large pixels, which could lead to error when aggregating into states. classification, that would have yielded more accurate results. Additionally, some layers I used included data for a majority of states, but not all of them, leading to an extensive, although not completely exhaustive, zonal statistics table.

| State | Climate Emigration Score (1= Low, 22= High) | | |
|---|---|---|---|
| | Median | Mean | Standard Deviation |
| Jammu & Kashmir | 17 | 16.28 | 1.31 |
| Himachal Pradesh | 16 | 16.06 | 0.91 |
| Punjab | 14 | 14.67 | 0.79 |
| Uttarakhand | 15 | 15.18 | 0.78 |
| Haryana | 15 | 15.43 | 0.90 |
| Delhi | 13 | 13.00 | 0.00 |
| Rajasthan | 11 | 11.46 | 0.81 |
| Uttar Pradesh | 16 | 15.80 | 1.18 |
| Bihar | 19 | 18.18 | 1.19 |
| Sikkim | 13 | 14.00 | 1.00 |
| Arunachal Pradesh | 15 | 15.59 | 1.22 |
| Nagaland | 13 | 13.29 | 1.16 |
| Manipur | 17 | 17.80 | 2.14 |
| Mizoram | 14 | 12.29 | 2.55 |
| Tripura | 20 | 20.00 | 0.71 |
| Meghalaya | 12 | 10.57 | 3.11 |
| Assam | 17 | 16.27 | 1.84 |
| West Bengal | 17 | 17.13 | 2.18 |
| Jharkhand | 16 | 16.16 | 0.61 |
| Odisha | 17 | 17.69 | 1.42 |
| Chhattisgarh | 12 | 12.00 | 0.88 |
| Madhya Pradesh | 13 | 12.73 | 0.81 |
| Gujarat | 11 | 10.71 | 1.79 |
| Maharashtra | 13 | 12.49 | 1.22 |
| Andhra Pradesh | 11 | 11.45 | 1.66 |
| Karnataka | 10 | 10.81 | 1.08 |
| Goa | 11 | 11.00 | 0.00 |
| Kerala | 14 | 13.83 | 0.80 |
| Tamilnadu | 11 | 11.36 | 1.67 |
| Andaman & Nicobar Islands | 12 | 12.00 | 0.00 |

The above table is based on 2011 Indian state data and does not include states for which there was no data.

## SOURCES


Hanna Carr

GIS 101: Introduction to GIS

May 8, 2018

Projection and Coordinate System:

WGS 1984 UTM Zone 43N, Transverse Mercator

Sources: ESRI, IndiaStat, The World Bank Group, UNEP/GRID, FMIS Bihar, The Times of India, BBC, The Economist, NASA, Black et. al 2013 (doi.org/10.1007/978-94-007-6208-4_2)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