Climate Change Markers and Refugee Flow

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Presentation Outline

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Dataset Introduction

- Climate change disrupts livelihoods and will induce
  - More extreme weather
  - Growing food and water insecurity
  - Rising sea levels
- Tens of millions of people have already fled their homes as refugees in the last few decades
- Analyzing the dynamics between climate change indicators and refugee flow from a country can reveal opportunities for interventions
- Three clusters of ecological hotspots:
  - Sahel-Horn belt of Africa, from Mauritania to Somalia
  - Southern African belt, from Angola to Madagascar
  - Middle East and Central Asian belt, from Syria to Pakistan

Research will focus on Middle East and Central Asian belt

Research Question

Our primary goal in this project is to understand if and how climate change predictors correlate with refugee flow from at-risk countries, focusing on data from the Middle East and Central Asian Belt.

Hypothesis

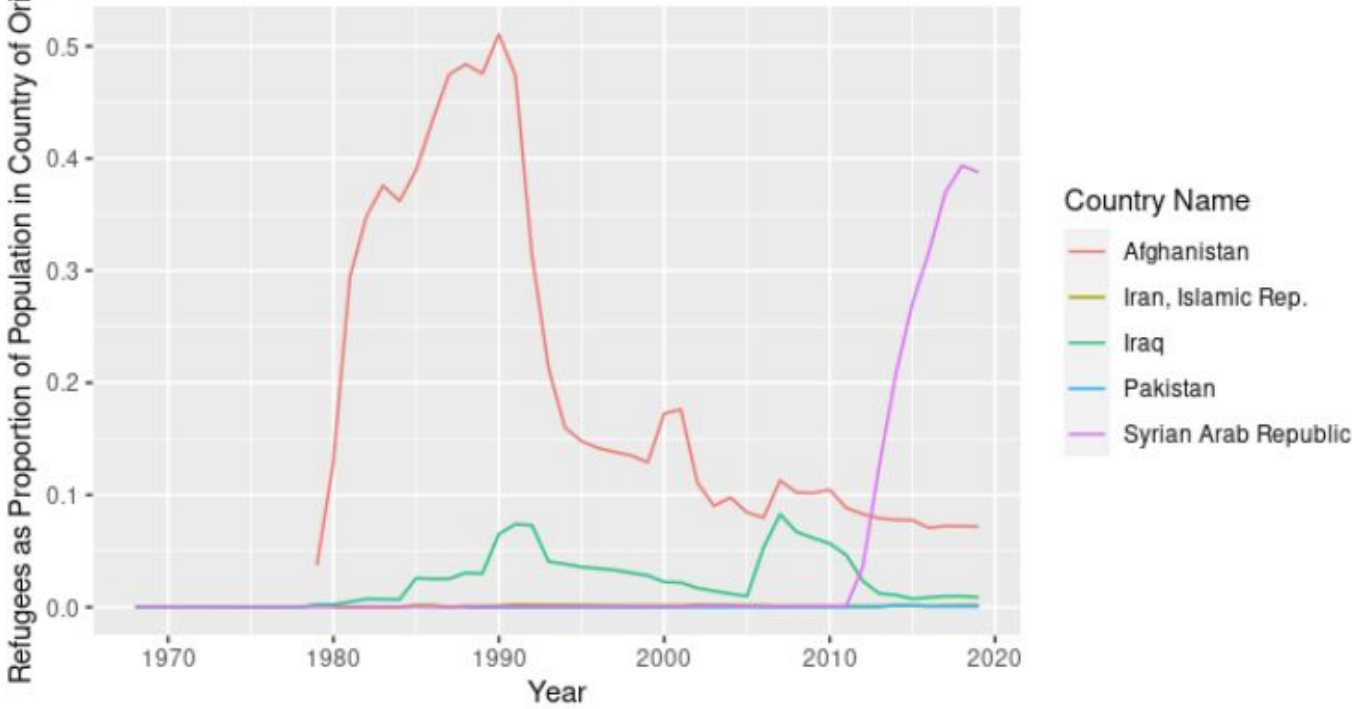
We hypothesize that at least one of the climate predictors (CO2 emissions in metric tons per capita, other greenhouse emissions in kilotons, and land under cereal production) in our linear model will have a statistically significant relationship with refugee flow from the countries in the Middle East and Central Asian Belt.

Exploratory Data Analysis -- Visualizing the Variables

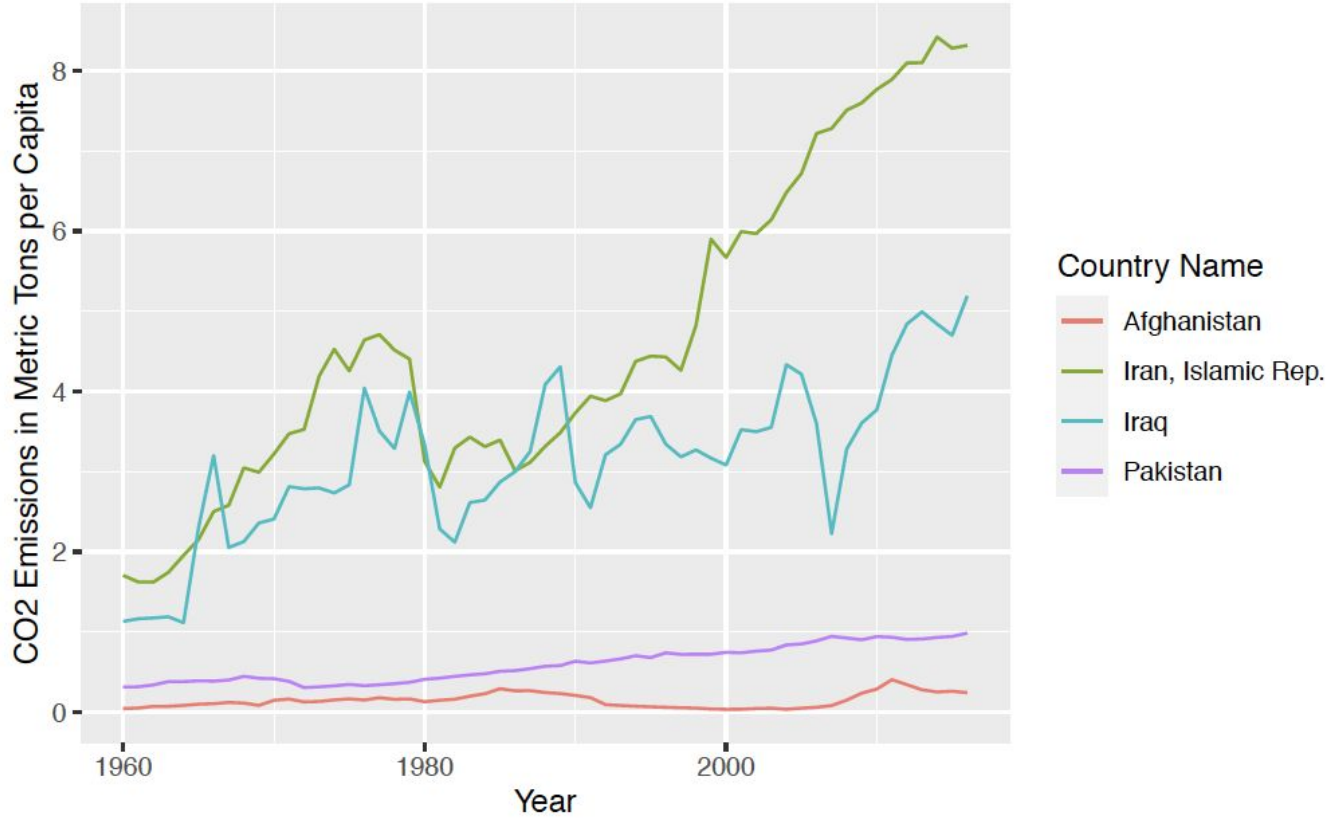
To visualize climate change predictors within each Middle Eastern country over time, the following explanatory variables were plotted against the yearly proportion of population leaving as refugees:

- CO2 emissions
- N2O emissions
- Methane emissions
- Percent of country's land that was arable
- Hectares of arable land used for cereal cultivation

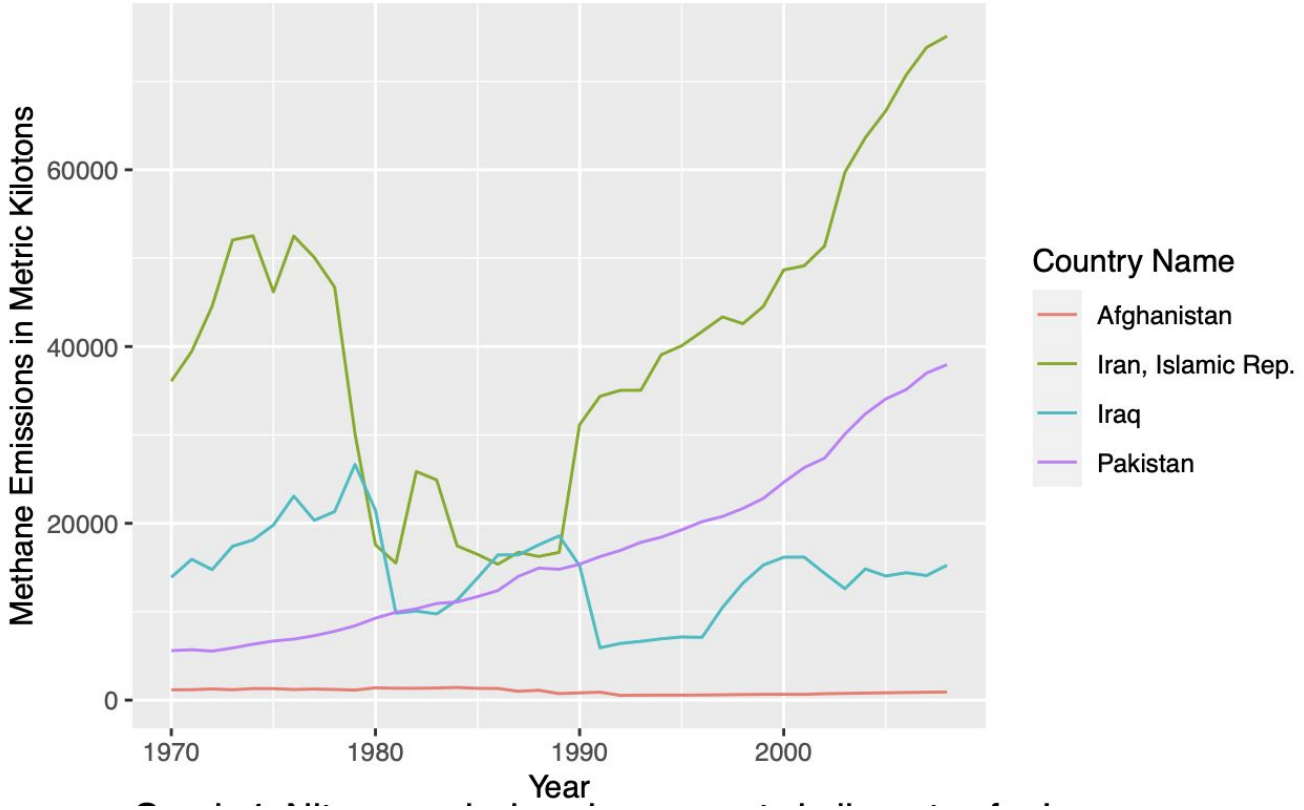
Graph 1: The proportion of total population that were reguees in Iran and Pakistan relatively similar, but increased sharply in Syria after 2011 civil war



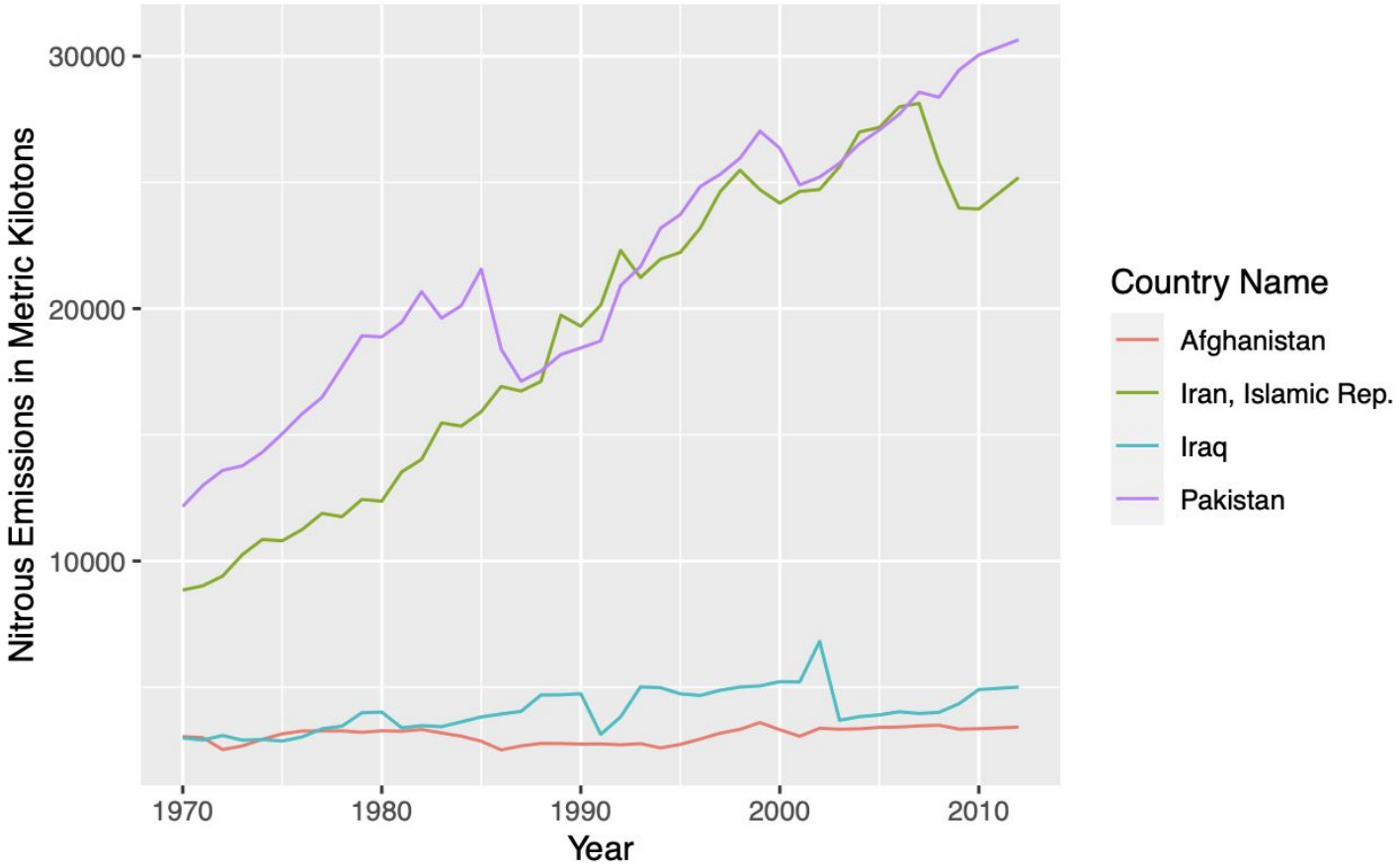
Graph 2: CO2 emissions in Iran and Iraq have higher relative increases over time compared to the other countries



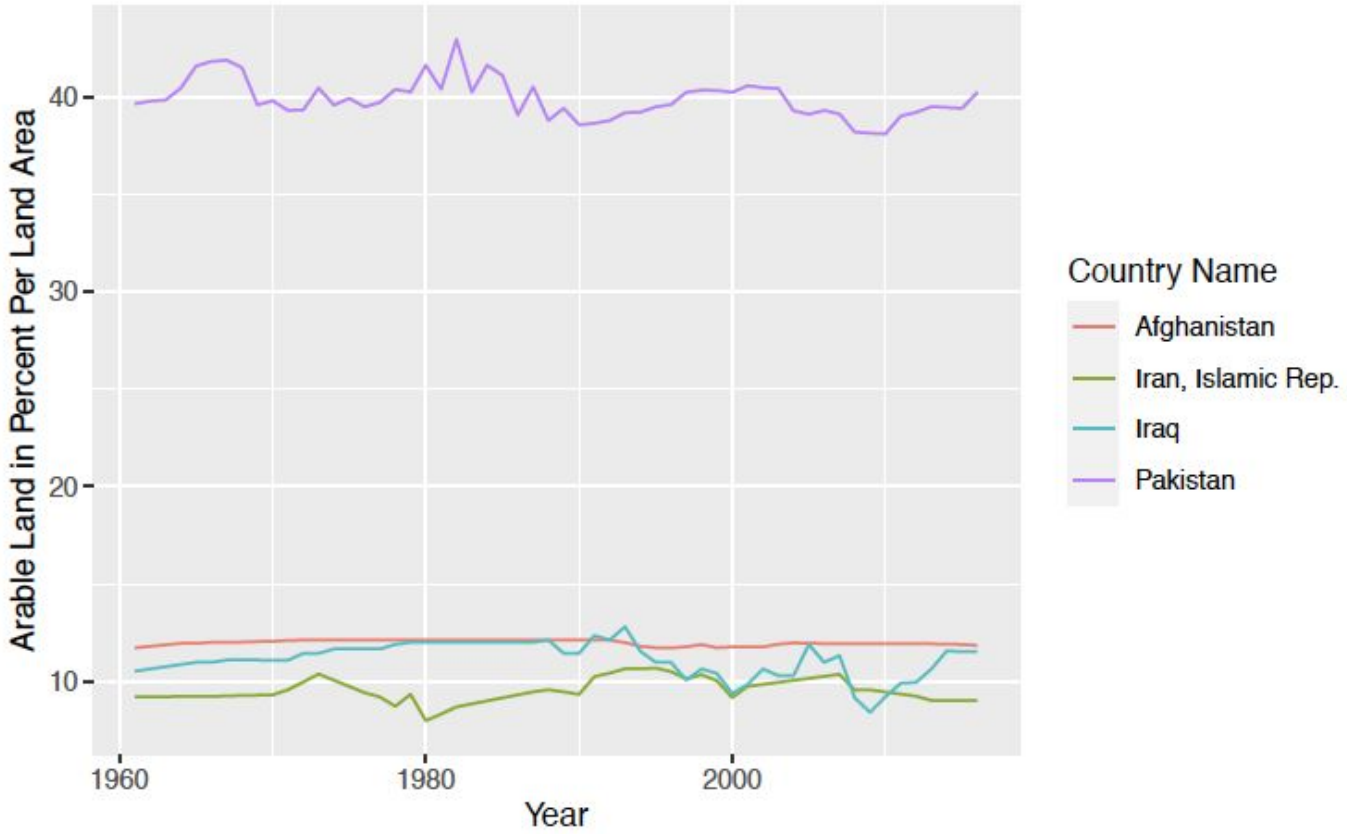
Graph 3: Methane emissions in Afghanistan remain relatively constant



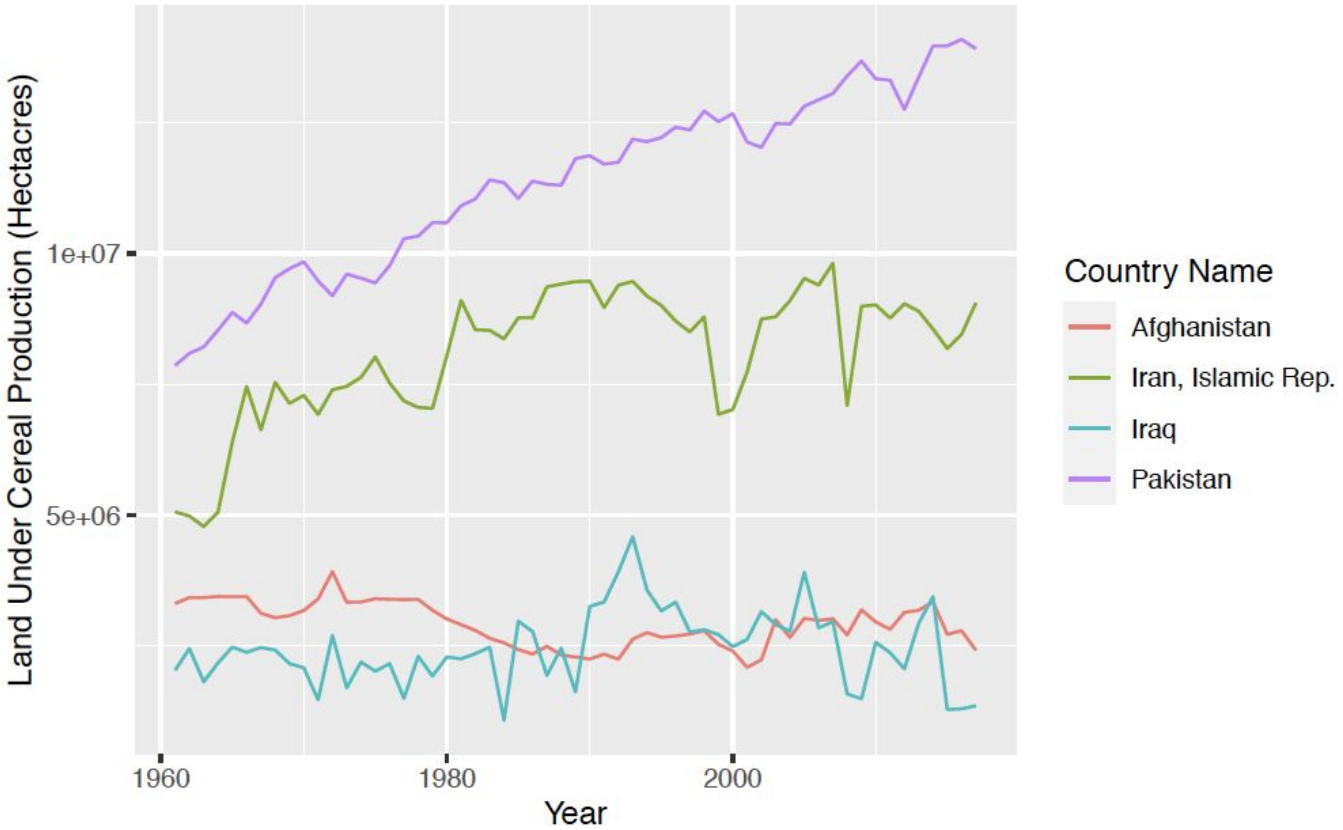
Graph 4: Nitrous emissions increase at similar rates for Iran and Pakistan



Graph 5: Percentage of arable land remained relatively constant for all four countries



Graph 6: Land under cereal production steadily increased for Pakistan and Iran



Methods

- Main effects linear regression with logarithmic transformation
- Diagnostics for linear regression
- Linear regression with logarithmic transformation and interactions
- Testing for multicollinearity
- Application

Main Effects Linear Regression Model Summary Statistics

- Predictors used: land under cereal production, CO2 emissions (tons per capita), nitrous emissions (kt), methane tons (kt)

  predicted log(proportion of refugees) = 7.004603e-01 - 1.584535e-06**land_cereal* - 3.723390e-01**co2_tons* + 4.499857e-04**nitrous_tons* - 5.452494e-05**methane_tons*

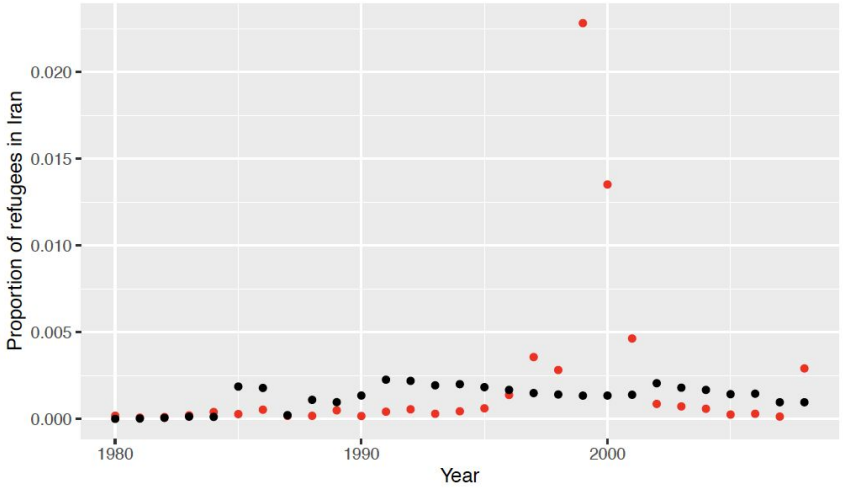
- The model developed for the Middle East Region had an R squared of 0.7998, and an adjusted R squared of 0.7923

Effectiveness of our Model

We wanted to see how well the predictions from model compared to actual data points from Middle East

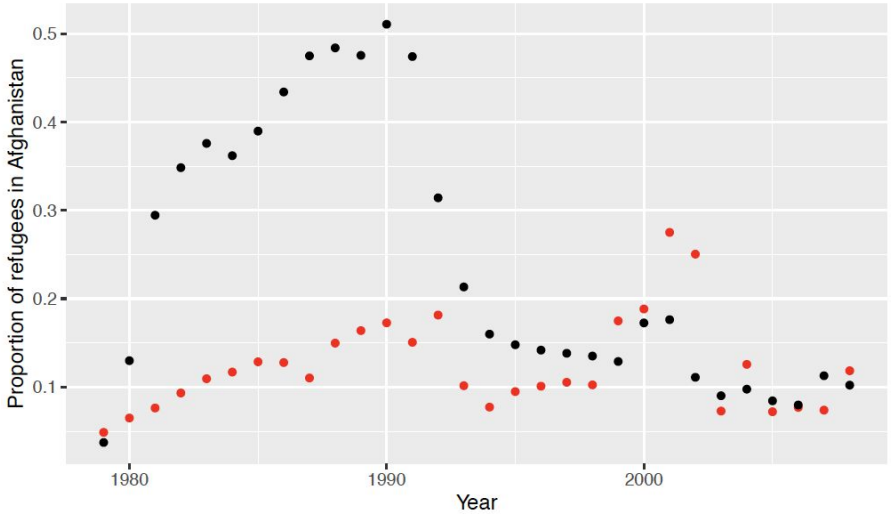
Graph 7: Predicted proportion of refugees in Iran relatively similar to observed proportion aside from 2 major outliers

Red points are predicted values and black points are observed values



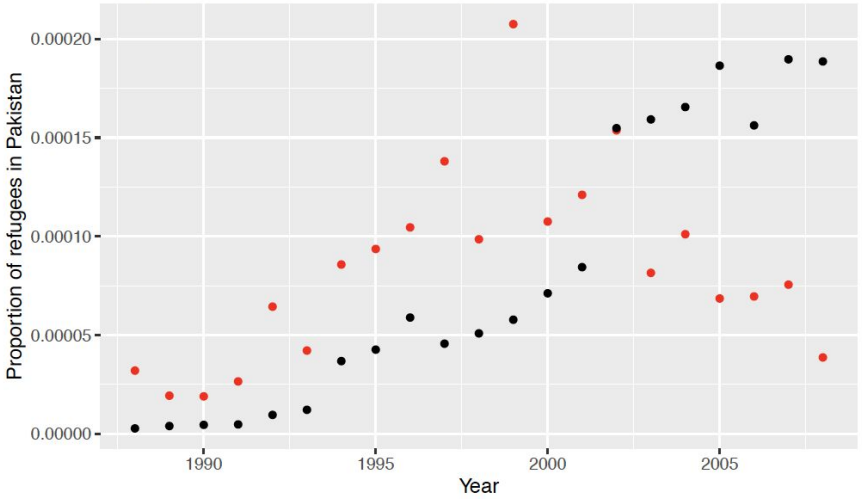
Graph 8: Predicted proportion of refugees in Afghanistan largely below observed proportion until 1995

Red points are predicted values and black points are observed values



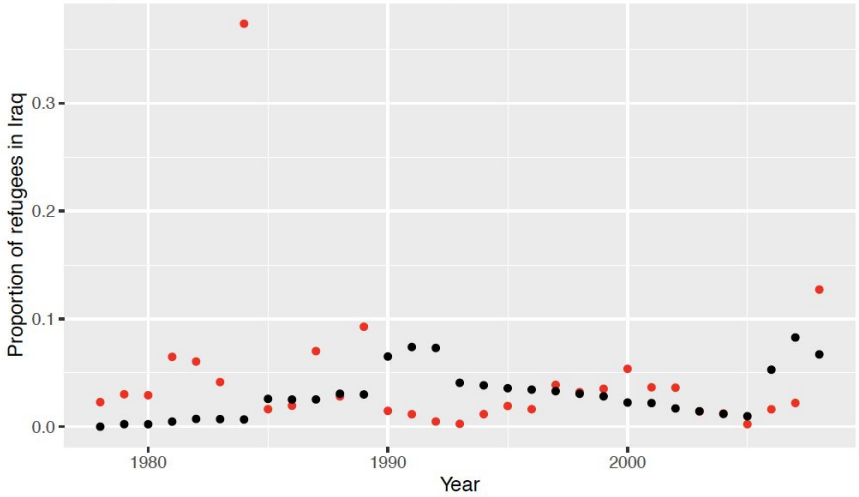
Graph 9: Predicted proportion of refugees in Pakistan above observed value until 2002

Red points are predicted values and black points are observed values



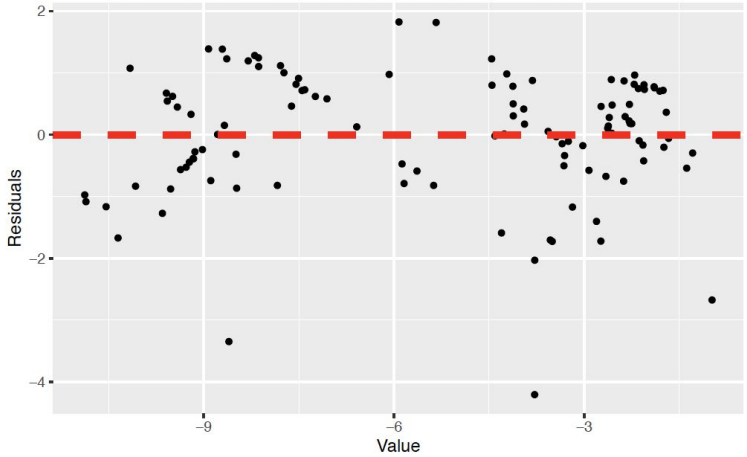
Graph 10: Predicted proportion of refugees in Iraq relatively similar to observed proportion aside from 1 major outliers

Red points are predicted values and black points are observed values

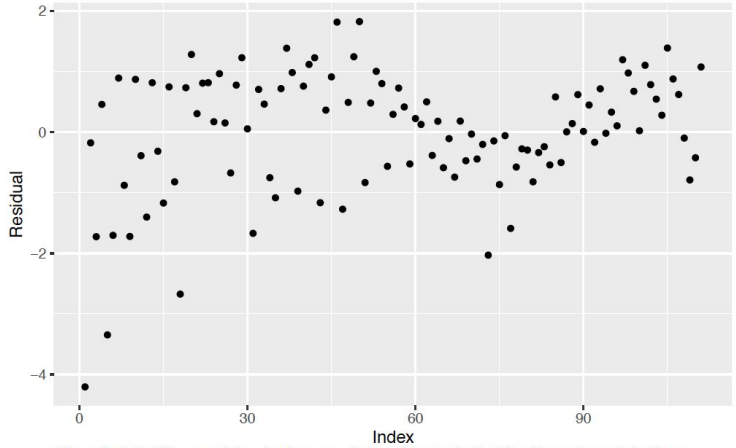


Diagnostic Plots to Test Conditions for Inference

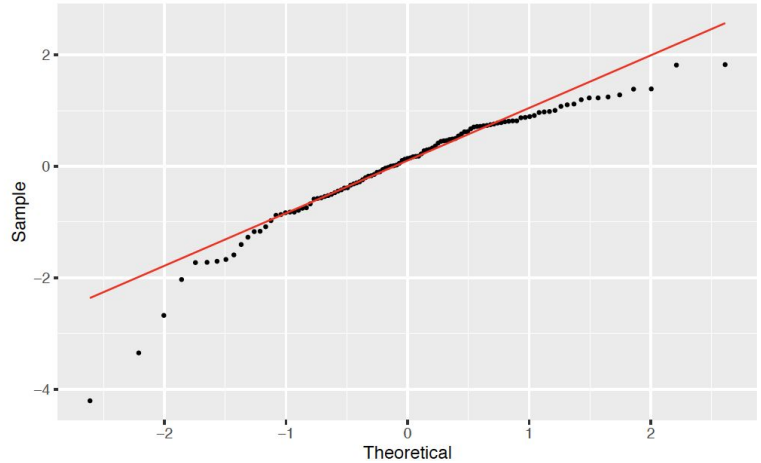
Graph 11: Residuals have realatively equal variance when plotted with the line y = 0



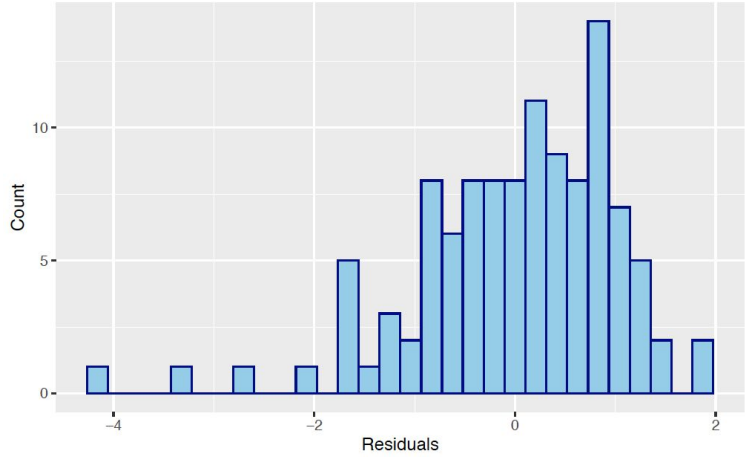
Graph 12: Residuals do not form any patterns or clusters, making them independent



Graph 13: The residuals do not form a normal distribution, invalidating the normality condition



Graph 14: The residuals form a left−skewed distribution, invalidating the normality condition



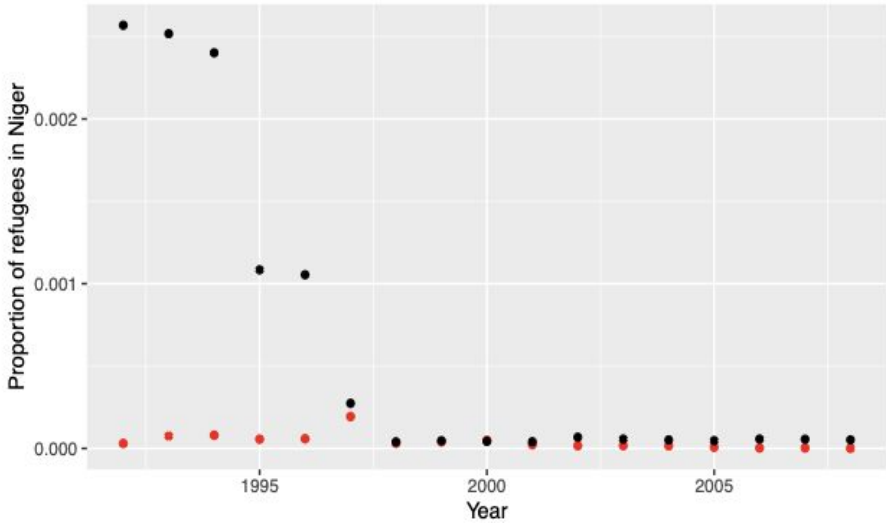
Application in Sahel Belt Region

- Sahel Belt region was chosen as a test for our model due to similar economic situations
- Conflict levels varied greatly in the region so countries with and without conflict were used for testing

Sahel Test Data

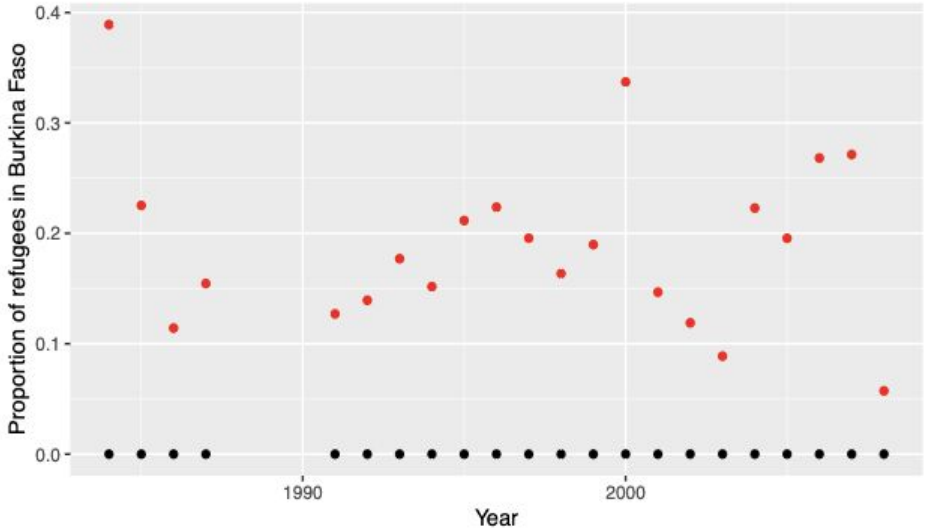
Graph 15: Predicted proportion of refugees in Niger mostly fit observed values after 1995

Red points are predicted values and black points are observed values



Graph 16: Predicted proportion of refugees in Burkina Faso higher than observed proportion of refugees

Red points are predicted values and black points are observed values



Results - Hypothesis Test

- Observed statistically significant relationships for percentage of land for cereal productions, metric tons of CO2 produced per capita, and kilotons of nitrous oxide produced
  - Exponentiated coefficient with largest effect: metric tons CO2 per capita
- Adjusted R squared value of .7923 for the main effects model
  - The model with interactions was not significantly different and did not warrant further exploration

Results - Main Effects Model Predictions

- Predicted values from the model fit observed data relatively well in Iran and Pakistan, but less so in Afghanistan and Iraq
- Application to Sahel Belt Region showed large overestimation in the case of Burkina Faso and relatively accurate predictions for Niger
    - Difference likely due to the need for some significant armed conflicts to incite initial refugee flow out of a country
- VIF scores for every predictor except for CO2 emissions were high (greater than 5)
    - Suggests a large degree of multicollinearity

Conclusion/Discussion

- Climate changer markers could be used to explain large amounts of variance in refugee outflow (with statistical significance)
  - However the conditions for inference were not met for the model
  - High degree of multicollinearity
- Some of the negative relationships are more obvious such as more land being used for farming leading to less refugee flow
- Some were less intuitive such as increasing CO2 emissions leading to less refugee flow
  - Likely because of economic development and increased living standards
  - May want to look into socioeconomic variables and see how if they have any effects
- Further investigation is warranted to quantify the impact of conflict on refugee flow, use more robust data that disaggregates type of refugees, and test other, nonlinear models

References

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