# Food Insecurity and Climate Change

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## Goal and Motivation

Climate change poses a significant global challenge, affecting people worldwide. Among its various impacts, food security is a critical area influenced by climate change. The alteration of weather patterns, reduced water availability, and diminished crop yields are just a few consequences. Our project aims to employ data science techniques to explore and analyze the adverse effects of climate change on agricultural production by predicting crop yield and investigating undernourishment across different regions around the world.

## Data

The three data sources for this project are from FAOSTAT crops and livestock products [1], FAOSTAT Food Security and Nutrition Indicators [2], and a global dataset on climate change indicators [3] built from 202 studies published between 1984 and 2020. We joined the Climate Change and Crop Harvest Datasets (i.e., [1] and [3]) on the Year, Country, Crop, and Domain fields to examine the relationship between climate factors and crop yield. The data in Datasets 1 and 3 span 190 countries and 32 years (from 1990 to 2021), while the data in Dataset 2 span 204 countries and 22 years (from 2000 to 2021). Our final datasets included the joined [1] and [3] Dataset and the FAOSTAT Food Insecurity Dataset [2].

## Model + Evaluation Setup

The two primary goals of our project are to predict crop yield based on climate factors and explore the prevalence of undernourishment across different regions of the world. To this end, we used the following two models: 1. A **Decision Tree Regressor** for predicting the yield of three crops (rice, maize, and wheat) based on climate data; 2. **DBSCAN** (a density-based spatial clustering algorithm) for clustering geographical regions of the world based on the similarity of the food insecurity indicators. We evaluated the performance of the decision tree regressor through MSE (mean squared error) and RMSE (root mean squared error). We also employed k-fold cross-validation for predicting crop yield. We tuned the hyperparameters for the DBSCAN algorithm to result in four distinct clusters in order to minimize the number of unclustered, outlier countries.

## Results and Analysis

**Question #1**: How does the decision tree regressor, trained using relevant climate factors, perform when predicting the yield of 3 crops (rice, maize, and wheat)?

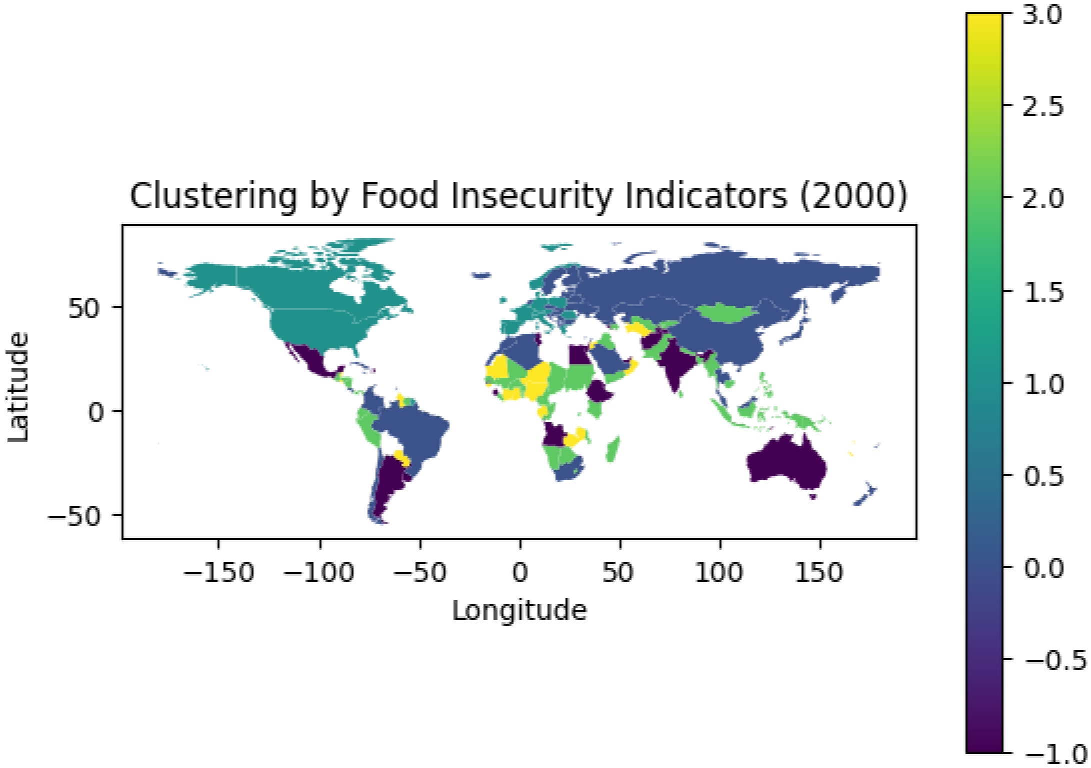
**Support for Question #1:** The following table demonstrates that our model could predict crop yield with a reasonable/satisfactory degree of accuracy.

| | |
|---|---|
| MSE | 0.4536 |

| | |
|---|---|
| RMSE | 0.6735 |
| Cross-validation score | 0.4262 |

**Question #2:** How does the prevalence of undernourishment distribute across different regions of the world?

**Support for Question #2:** The following plot demonstrates the clusters for 26 food insecurity indicators.



# Socio-historical Context and Impact Report

## Socio-Historical Context

We rejected our hypothesis "There is a significant correlation between $CO_2$ ppm and crop yield in the dataset." Initially, we were surprised by this result – we assumed that there would be a positive correlation between $CO_2$ ppm and crop yield. Upon further research, we discovered that the relationship between $CO_2$ and crop yield is shaped by a number of complex factors. For example, the "$CO_2$ fertilization effect" posits that atmospheric $CO_2$ stimulates plant growth and photosynthesis, which can lead to increased crop yields. [1] But taking into account larger societal relationships, we can also consider $CO_2$ emissions in the context of industrialization and the widening inequality between Global North and Global South. $CO_2$ emissions are a primary driver of global climate change, and it has led to a variety of environmental crises that can also affect food security: changes in temperature and rainfall patterns, extreme weather events such as floods, droughts, and heat waves, and limited access to resources. In other words, the results suggest that our hypothesis and framework of analysis are heavily influenced, and often confounded, by factors across various (biological, social, political) dimensions.

The major stakeholders in our project include farmers and agricultural workers who may be impacted by changes in weather patterns and agricultural practices, the plantations/greenhouses, the food industry, including retailers and manufacturers, as well as government and policymakers responsible for food insecurity and climate change related policies. [2] As creators of our project, it is important for us to consider the needs, perspectives and concerns of our stakeholders. Our goal is to ensure that our project benefits the stakeholders in some way, such as providing them with new insights or information that could affect their decision-making process.

Some of the most relevant research that has been conducted about our project topic has reached the following conclusions: changing weather patterns and extreme weather events negatively affect crop yields; more sustainable agricultural practices and reducing greenhouse gas emissions could reduce food insecurity by improving food productivity, reducing food waste and enhancing food access; global food loss and waste produce around 8% of total anthropogenic greenhouse gas emissions, which contributes to climate change and food insecurity. The existing research has made significant societal impact, such as raising awareness of the multifaceted challenges posed by food insecurity and climate change and bringing into attention the urgent need for action to address the underlying causes. [3]

## Ethical Considerations

Some underlying historical or societal biases in our data may stem from accessibility to data and methods of data collection across different countries. For example, political instability or conflict may make it difficult to collect and share data, particularly in countries experiencing conflict or civil unrest. Furthermore, lack of infrastructure (i.e. limited funding or technical expertise) or strict privacy / confidentiality policies can also affect data collection and sharing practices of certain countries. Therefore, it is crucial that organizations continue to engage with local stakeholders and organizations to overcome data collection obstacles. [1] After evaluating the results of our statistical tests, all of our hypotheses seem to result in the expected result except our hypothesis regarding irrigation. We think that the data in nation's that do not use irrigation may be sparse due to the aforementioned infrastructure issue.

Our primary data source is the Food and Agriculture Organization of the United Nations (FAOSTAT). FAOSTAT provides free access to food and agriculture statistics (including crop, livestock, and forestry sub-sectors) for over 245 countries. Given that their mission is to "improve data collection and dissemination for development and the fight against global hunger and malnutrition," our data analysis efforts are consistent with the intended usage of the database. Furthermore, this implies that the collection and aggregation of this data is done through transparent measures and will not impact any individual or particular community's privacy.

It is important to note that FAOSTAT primarily collects data through questionnaires that are submitted to countries members on a regular basis. While pursuing this data, these organizations must also consider that factors may inadvertently favor certain minority groups. Therefore, FAOSTAT must continue to conduct research to investigate potential influence, and continue to craft careful questionnaire design as biases fluctuate. In terms of privacy, these questionnaires must enforce anonymity in order to mitigate the collection of personally identifiable information. Although FAOSTAT underlines potential biases in yearly impact reports, we did not take this into account when using the data for our own analysis purposes.

One possible misinterpretation of our project results is the mistaken belief that climate change is the sole cause of food insecurity. Other impacts such as poverty and political instability have large impacts on food insecurity; climate change is just one contributing factor. Further, another possible misuse of the results is neglecting the disproportionate impact of food insecurity and climate change on vulnerable populations, such as low-income communities. To prevent this problem, we included an analysis on the prevalence of undernourishment in different regions of the world to highlight the relative impact of food insecurity on disadvantaged regions and populations.

# Works Cited

[1] “A Call to Action by Stakeholders: United States Food Loss & Waste 2030 Reduction Goal.” *EPA*, www.epa.gov/sustainable-management-food/call-action-stakeholders-united-states-food-loss-waste-2030-reduction. Accessed 12 May 2023.

[2] Cho, R., & Cho, R. (2022, January 27). How climate change will affect plants. Lamont. Retrieved May 3, 2023, from https://lamont.columbia.edu/news/how-climate-change-will-affect-plants

[3] Kaplan, Sarah. “A Third of All Food in the U.S. Gets Wasted. Fixing That Could Help Fight Climate Change.” *The Washington Post*, 25 Feb. 2021, www.washingtonpost.com/climate-solutions/2021/02/25/climate-curious-food-waste/.