# Environmental impacts of food production and consumption

Vaishnavi Lalwala, Sargam Malaviya, Dhvani Chokshi

Computer Engineering, School of Technology, Pandit Deendayal Energy University, Gandhinagar, Gujarat

## Abstract:

Food production and consumption play a critical role in shaping environmental sustainability. This paper examines the environmental impacts of food production and consumption, emphasizing the use of Life Cycle Assessment (LCA) to quantify these effects. Comparisons between open and indoor farming practices highlight resource usage and environmental burdens. Additionally, Artificial Neural Networks (ANN) are explored for optimizing agricultural processes such as methane production and crop yield prediction. Despite data challenges, researchers employ imputation methods and visualization techniques to communicate nuanced insights. Understanding these impacts is crucial for fostering sustainable food systems.

## Introduction:

In the realm where sustenance intertwines with ecological stewardship, the intricate dynamics of food production and environmental impact unfold. This paper embarks on a meticulous examination of this intricate interplay, leveraging Life Cycle Assessment (LCA) as our guiding tool through the intricate terrain of agricultural practices and consumption habits. We scrutinize the dichotomy between conventional open farming and emergent indoor cultivation techniques, while also exploring the potential of advanced visualization techniques to illuminate pathways toward sustainability. Amidst the complexities of data, our mission remains resolute: to shed light on avenues toward a more environmentally conscious food landscape. Visualizations offer a compelling means to decipher intricate relationships within agricultural systems, allowing us to grasp complexities with clarity and insight. From spatial distribution maps revealing ecological footprints to dynamic charts illustrating resource flows, these visual tools empower us to comprehend and communicate the multifaceted impacts of our food choices. Additionally, our quest delves into computational prowess, where Artificial Neural Networks (ANN) emerge as potent tools for optimizing agricultural processes. Visual representation serves as a powerful conduit for unraveling complex data landscapes, offering clarity amidst the intricacies of agricultural systems. Through intuitive graphs, charts, and interactive models, visualization transforms raw data into actionable insights. It enables us to discern patterns, identify inefficiencies, and envision innovative strategies for sustainable food production. As we navigate through this paper, visualizations will serve as our guiding light, illuminating the way towards a greener, more resilient future.

## Dataset Description:

1. **FAO 'Food Balance Sheets' Dataset:**
    - Source: Food and Agriculture Organization of the United Nations (FAO)
    - Description: This dataset provides comprehensive information on the food supply patterns of 174 countries spanning from 1961 to the latest update available in 2013. The data is measured in 1000 tonnes units, offering

insights into the quantity of various food items available for consumption in each country over the specified time period.

2. **'Environment Impact of Food Production' Dataset:**
    - Description: This dataset focuses on the environmental impact of food production, encompassing 43 commonly consumed foods grown globally. It comprises 23 columns representing various environmental metrics such as land usage, water consumption, and carbon footprints associated with the production of each food item. These metrics are expressed in kilograms of $CO_2$ equivalents per kilogram of food product, covering different stages in the lifecycle of food production.

## Literature Survey:

Life Cycle Assessment (LCA) is pivotal for quantifying environmental impacts across product and service life cycles, particularly in comparing open and indoor farming practices due to its comprehensive approach. Assessment often relies on key indicators like water, carbon, and ecological footprints, offering insights into resource use and environmental burdens. Computational methods like Artificial Neural Networks (ANN) are increasingly applied, demonstrating efficacy in optimizing agricultural processes such as methane production and crop yield prediction. Addressing data challenges, researchers utilize various imputation methods and feature compression for complex datasets. Visualization techniques including catplots, heatmaps, and boxplots aid in communicating nuanced insights, such as product-specific emissions and operational impacts across the value chain.

## Project Implementation:

1. Data Exploration, Cleaning, and Transformation:
    - Begin with a standard approach to explore the dataset, examining variable names, types, content, and overall structure to gain a comprehensive understanding of the data.
    - Clean the data by removing unnecessary rows and columns, handling missing data, and eliminating duplicates.
    - Transform the 'Food Balance Sheets' dataset for improved visualization and data handling, addressing negative values where necessary.
2. Handling Missing Data: Imputation Methods:
    - Identify the "Missing Not At Random" (MNAR) archetype in the dataset, indicating a systematic bias in the missing pattern.
    - Evaluate various imputation methods including dropping columns with missing values, imputation by average value, median, K nearest neighbors (KNN), multiple imputation by chained equations (MICE), and custom-fitted imputation methods.
    - Choose three columns with the highest amount of missing values as examples to illustrate the results of each imputation method and compare the differences in mean values after each method.
3. Visualization and Analysis:
    - Set up visualization tools and frameworks.
    - Implement MICE imputation using Bayesian Ridge as the chosen method for dealing with missing values.
    - Generate a useful overview visualization depicting Total Emissions by each Food Product, filtered by food Category, to provide insights into emission patterns across different food categories.

- Create tree maps to visually represent the distribution of emissions by product category.

## Expected Outputs:

1. **Top of List for Total Emissions:**
   - Identify the food products with the highest total emissions, providing insight into the primary contributors to environmental impact within the dataset.
2. **Useful Overview Visualization of Total Emissions by Food Product and Category:**
   - Create a visualization showcasing total emissions by each food product, filtered by food category. This visualization offers a comprehensive understanding of emission patterns across different food categories.
3. **Food Supply vs. Population Increase:**
   - Analyze the relationship between food supply and population increase over time, shedding light on the dynamics of food production and consumption in relation to population growth.
4. **Impact of Water Usage on Emissions:**
   - Investigate the influence of water usage on emissions, exploring the correlation between water consumption and environmental impact within the context of food production.
5. **Correlation Analysis of Variables Influencing Total Emissions:**
   - Utilize a "coolwarm" heatmap and pairplot to visually depict the correlation between total emissions and other relevant variables. This analysis aims to identify key factors influencing emissions within the dataset.
6. **Emissions by Product Category:**
   - Examine emissions distribution across different product categories, providing insights into the relative environmental impact of various food categories.
7. **Agriculture Operational Emissions by Value Chain:**
   - Assess operational emissions along the agriculture value chain, highlighting emissions associated with different stages of food production, processing, and distribution.
8. **Creation and Visualization of a Normalized Variable Index:**
   - Develop a normalized variable index to condense complex emission data into a meaningful format. By aggregating multiple emission-related variables, this index facilitates a concise overview of environmental impact for both individual food products and categories. Visualizations of the index enable stakeholders to glean insightful summaries without overwhelming them with numerous graphics.

## References:


1. Estimating energy consumption and GHG emissions in crop production: A machine learning approach.
   Saeed Sharafi [a b], Ali Kazemi [a b], Zahra Amiri .

https://www.sciencedirect.com/science/article/abs/pii/S0959652623014002#preview-section-references.

2. Using the Machine Learning Method to Study the Environmental Footprints Embodied in Chinese Diet

   by Yi Liang [1],Aixi Han [2],Li Chai and Hong Zhi

3. Life Cycle Assessment- G. Finnveden, J. Potting, in Encyclopedia of Toxicology (Third Edition), 2014

4. Environmental impacts associated with food production

2021 | Dr Martin Juneau, M.D., FRCP
5. Food production is responsible for one-quarter of the world's greenhouse gas emissions By: Hannah Ritchie *November 6, 2019*
6. Analysis, Visualization, and Extensive Imputation of CO2 Emissions in Food Products.
7. Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice To cite this article: Michael Clark and David Tilman 2017 Environ. Res. Lett. 12 064016